THE ENGINEERING RECORD

PUBLISHED WEEKLY BY THE

McGraw Publishing Company

MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Canada, Cuba and Mexico...$3.00 a year.
Foreign subscription ....$6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGES OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to September, 1904, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgement of assistance rendered by subscribers in the securing of new orders a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1906, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 14,000 copies are printed. Total circulation for 1906 to date 677,000 copies, an average of 13,019 copies per week.

TABLE OF LEADING ARTICLES.

The Automobile for Engineering Purposes........ 707
The Study of Water Powers.................... 707
Impact Tests of Timber........................ 708
Higher Wages and Decreased Expenses............ 708
The Substructure of the West Street Building, New York. (Illustrated) 710
The Pittsburgh Filtration Plant.—IV. (Illustrated) 713
The Tidewater and Deepwater Railways.—III. (Illustrated) 719
The Warming and Ventilation of Churches, Halls and Theaters. (Illustrated) 724
Description of a Cold Storage Plant Utilizing Exhaust Steam. (Illustrated) 725
Operating Experience with 4-Stage Curtis Turbines 726
Strengthening a 250-ft. Chimney. (Illustrated)... 727
Adjustable Connection of Anchor Arm Lateral System, Quebec Bridge. (Illustrated)............. 728
Unusual Details of a Reinforced-Concrete Floor. (Illustrated) 730
Fluorescein in the Study of Underground Waters 730
Cost of Steam Shovel Work..................... 732
Tests of Bond Between Concrete and Steel at the University of Illinois 732
Book Notes 733
The Victoria Falls Development................. 734
The Design of Slabs 734

The Automobile for Engineering Purposes.

The engineering journals have been rather remiss during the past year about calling attention to the remarkable developments of the field of usefulness of automobiles in their work. It is rather amusing to read in the journals devoted to motor cars about the poor roads tourists find in various places where engineers and contractors have been using such vehicles all the season with much satisfaction. Probably any tourist who struck across the Nevada desert to Goldfields under average conditions would fail to discover a superabundance of fun in the trip, but the residents there who use the automobile now in place of the former horse and mule teams know what a great help the advent of the former has been. The motor car is a troublesome vehicle at times, but a good one in skilful hands will do better than a horse on most roads, although the traveling may not be so comfortable. As a concrete case illustrating this fact, reference may be made to the trip over the proposed Owens River conduit line of the Los Angeles water-works, made by Messrs. Stearns, Freeman, Schuyler, Mulholland and Lippincott a couple of months ago. The first three engineers, who are the consulting engineers of the project, made the trip of some five hundred miles in order to become familiar in a general way with the topography of the country and the river in the vicinity of the proposed headworks of the aqueduct. The trail is a very rough one in places, snow and sleet made the going very hard at times, and once the wind blew so fiercely that the fires of a steam car were affected. In places it was necessary to push the three cars through the bad stretches of road, and on one occasion a path had to be shoveled laboriously through the snow. The radiator of one of the three cars was put out of commission by freezing, a spring broke, something went wrong with the condensing apparatus of the steam car so that it consumed water while crossing the Mojave desert in a most criminal way, yet the party kept up to schedule and only one accident occurred, and that on the last day of the eleven-day trip, which could not be repaired without getting extra parts. The journey would have been impracticable in the same time and under such conditions of weather with any other method of transportation. It may be doubted, however, if such a trip would appeal, to any of those who took it, as a pleasure tour.

So far as The Engineering Record has been able to ascertain, the best results for such rough work are obtained with cars of light or medium weight, short wheelbase and plenty of cooling capacity. There is little to be said in favor of the heavy, high-powered luxurious touring cars on such roads for business purposes. The short wheelbase is needed to make the sharp turns that occur on these trails, where boulders and stumps must be avoided and the road itself doubles about like a steel tape in the bushes. This short length also saves some weight, which is very desirable in order to have power for plenty of baggage or for five passengers. Finally the arrangements for cooling must be very good, for rough roads require long runs on low speeds which are particularly likely to cause overheating of the cylinders. These requirements do not mean expensive cars; fine service has been given on rough roads by cars costing under $2,000 in the hands of people who understand them. In one very sandy section of New England which tourists detest on account of its loose roads, a local physician with a large practice has been able for several years to do better traveling with a single-cylinder runabout than with two good horses which he formerly kept. Another thing to be considered in studying the automobile as a means of getting about on engineering work is the general arrangement of the body. Most touring cars are not finished for hard service. The upholstery is too poor and there is too much of it. An engineer buying a car would do well to visit the factory and see if he cannot save room for his baggage by having the body finished in a style different from that of stock cars. There is a lot of waste space about most automobiles which could be utilized to great advantage for supplies and luggage if careful attention was paid to the subject.

So far as motor trucks are concerned, it is safe to say that they are only useful on fair or good roads. Those that are now built are either electric vehicles capable of operating only within a short distance of a station where their batteries can be charged, or low-powered gasoline trucks which are unable to run on poor roads. Unless a contractor can be sure of fair roads there is little prospect of success in hauling supplies with automobile wagons. Heavy teaming will cut up a dirt road badly, and a bad dirt road is not the place for the present standard low-powered gasoline truck. With higher power, there are all sorts of tire complications to be considered. It is hard enough to drive a touring car over a muddy or sandy road, even with chains on the rear wheels, but the difficulties are increased many times with the much heavier trucks. The good points of mechanical traction are so attractive, however, that contractors are beginning to look into the practicability of maintaining good roads on work lasting some time, so as to put on motor vehicles and thus do away with the troubles due to the upkeep of teams and animals. The log drag as a means of keeping a dirt road in good condition has been receiving a good deal of attention from contractors of late, and it would not be at all surprising if some of them made a careful study of its real capabilities this year, so as to ascertain if it is practicable with its aid to keep a dirt road passable for motor trucks. The problem is not one of getting good automobile wagons, for they are in regular service in many cities, but rather of securing roads fit for their use. This reduces the subject to the hoary-headed topic of cheap road building, which it is hardly necessary to refer to here further than to say that anybody interested in it should secure from the Office of Public Roads in Washington copies of their excellent bulletins on the subject. While The Engineering Record does not expect to see any extensive use of motor trucks on contracting undertakings for a good many years, it would not be at all surprised to learn of their sporadic introduction during the coming year and their gradual growth in favor where the roads are good enough for them.

The Study of Water Powers.

One of the remarkable consequences of electric power transmission has been the stimulus given to men's eyes and intelligence in prospecting for water powers. The general regions in which water powers are to be found are fairly well known, but even the best known of them have not yet been fully explored and only within a very few years has intelligent exploration begun. Yet in spite of this brief time valuable finds have been numerous. If a productive coal mine were opened, let us say, in Vermont, the state would be fairly raked from end to end in a few months in hope of finding another. Water power is more valuable to-day than most forms of mineral wealth, yet important hydraulic opportunities exist year after year unrecognized and unappreciated within easy reach of the communities that would be directly helped. People who would rise to the situation and hustle at the sight of an outcropping of the meanest lignite seem capable of walking with eyes shut right by a valuable water power. The ordinary well-informed business man would take notice of any kind of a mine, but remain perfectly impassive when told of a thousand horse-power water privilege in the next town. Even in Massachusetts, one of the most fully developed States from the standpoint of manufactures, an almost unsuspected privilege with some hundreds of feet of available fall has been found and is now being developed. There are others quite as good which have not been developed yet. Vermont is well provided with good powers if people will only stop to look for them, and what is true of these old and well-known States is to an even greater degree true of the newer ones.

Within a few months on one of the best-known New England rivers a new and important power has been found, and such is the story all over the country wherever intelligent exploration has been carried out. In the admirable work of the Geological Survey much valuable information has been made available, and much more might be done if provision were made for systematic hydraulic reconnoisance. A field geologist if expected to look out for and report upon water powers can do admirable work. His big aneroid will give him differences of head with sufficient precision, and were he authorized to do the work he could get preliminary gaugings at very small expense. Too much stress can hardly be laid upon the value of systematic gaugings kept up from year to year, and within its means the Geological Survey has done admirable work in this particular. But it must be followed up, for granting the existence of a water power its commercial value depends largely upon its natural or artificially possible permanence. Given a stream with a fall it is no difficult matter to explore it for possible storage which determines its value for power or irrigation purposes. The added work is not considerable, but it is more than a hard-worked department can do without additional resources, and if the work of exploration and gauging is to be done with proper promptness liberal provision should be made for it. This journal has already reported that the funds available for the hydrographic work of the Geological Survey were seriously cut down at the last appropriation. The same blunder should not be repeated during the present session of Congress, and the engineering profession should throw what weight it can toward encouraging liberality for the future. If each engineer who appreciates the value of this feature of the work of the Geological Survey would take pains to see that his particular Congresssman is posted on the importance to the community of well-directed hydrographic effort, the narrow policy of last year will not be continued. The subject is of general public interest as developing the Nation's wealth, and it should not be put aside. It is worth concerted and vigorous effort.

Impact Tests of Timber.

Impact tests of any material whatever involve serious difficulties if the attempt is made to obtain reasonably accurate results. The application of loading in the usual tests of tension, compression and bending can be made under perfectly well-defined conditions, so that no element of sensible uncertainty enters the work. The actual loads are easily measurable and gradually applied, it being of little consequence what the rate of application may be within comparatively wide limits. The conditions in impact tests on the other hand are constantly involved in uncertainty unless the most scrupulous care is exercised, and even then there will be almost inevitably serious lack of definition somewhere. These conditions become more aggravated as the stiffness of the material tested decreases and as the elastic properties become less pronounced.

In the impact tests of pieces of steel if the energy of the impact is accurately measured, as it may easily be, the local yielding either at points of support or points of application is so small that it may be considered negligible under suitable conditions of test. Again the elastic properties of steel are so nearly perfect below the elastic limit that there can be little opportunity for expenditure of energy other than by producing elastic deformation, and even when the impact tests of steel are carried far above the elastic limit it is not excessively difficult to account quantitatively for the expenditure of the energy of impact. In testing timber, however, fundamentally different conditions exist.

Timber is emphatically of heterogeneous texture, so to speak. Its fibres are not continuous nor are the longitudinal fibres in general parallel to the axis of the piece in full size sticks. The resistance to longitudinal shear is low and variable even in different parts of the same stick. The elastic properties of timber are so highly imperfect that it might be said, without exaggeration, they are practically non-existent. The influence of time in producing distortion, under loads of magnitude, is quite pronounced, so pronounced, in fact, that it must be taken into consideration under large loads, although they may be far below the ultimate. Again, the modulus of elasticity of timber, by no means well defined for the reasons just stated, is very small and comparatively large distortions at right angles to the fibres are produced with small loads, especially under impact. In impact tests of beams, whether large or small, both the loading and the reactions are exerted in a direction across the fibres with the inevitable result of considerable permanent distortion unless the utmost care is exercised in designing the details of the testing appliances at those points.

If, further, there be added to these considerations the influences of the usual natural defects of the timber, such as small or large knots, wind shakes, season cracks and spots of incipient decay, all of which are more or less found in structural timber, it can readily be seen that the energy of an impact test may be largely expended as work performed in doing many things in the interior of a beam which are far outside of elastic or other deformations of such a homogeneous material as structural steel. All these considerations must be given due allowance in the impact tests of timber if the results are to be fairly correct.

As noticed in a short article in The Engineering Record of Dec. 22 of the current year, the Forest Service of the Department of Agriculture has been, and is, investigating the resistance of timber to impact loads. The result is already announced that wood shows more elasticity under impact than with gradually applied loads. This class of results as disclosed in the testing machine is entirely consistent with what has long been known and recognized as the influence of time in timber tests, and it probably signifies little or nothing more. The conclusion that a higher elasticity is exhibited under impact than under static loading should be accepted only with the above qualification. In experimenting with such a material as timber where it is known that a considerable part of the internal work performed by applied loads is not of a truly elastic character, it is imperative that great caution should be exercised in applying the ordinary formula of the common theory of flexure, and postulating corresponding conclusions. The fact that a timber beam may deflect twice as much in the one case as the other, does not necessarily indicate that the intensity of fibre stress will also be twice as great, especially with high loadings. The well-known low value of the resistance of timber to longitudinal shear makes it certain that a part of the deflection, and it may be a substantial part, resulting from an impact test of a beam is due to the slipping of the fibres over each other, so that the actual intensity of fibre stress may be materially less than the value computed by the usual deflection formulæ. Such a result would be aggravated by the natural defects of the timber to which allusion has already been made.

These observations are stated, not for the purpose of discrediting the results of impact tests of timber made by the Forest Service, but to indicate some of the difficulties which are involved in this class of investigation work. They show also the imperative necessity of the greatest caution both in applying the formulæ of the common theory of flexure in the cases under consideration and in formulating conclusions from the application of those formulæ. In fact, it would be well in these investigations to determine as closely as practicable, the modulus of elasticity of longitudinal shearing and then employ the formula for deflection which includes both the effects of shear and the direct strains of tension and compression. Even then all the effects of longitudinal shear would not be provided for.

It is a little disturbing in these government tests to find that such small beams as 2-in. by 2-in. cross-section with 34-in. spans are being employed in both static and impact tests. Such test pieces are always selected and belong to a quality of timber far better in character than that of full-size timber beams used for structural purposes. This feature of former timber testing in the Department of Agriculture has been severely and unanswerably criticised. These diminutive specimens cannot possibly give safe values for the full size sticks used by the engineer. It is obviously more costly and more difficult to test the latter than the former; but if careful and extensive testing is to be undertaken it should be so done as to give results of value whether the cost and the difficulties be great or small.

Higher Wages and Decreased Expenses.

One of the most characteristic features of the American workmen is their custom of shifting from one position to another whenever a trifling increase of wages is offered. It is frequently mentioned by visitors from Great Britain and Europe, where men change employment far less often. This habit is not a good one for men or employers, for it destroys the feeling of mutual reliance and respect which is at the bottom of all efficiency. One reason for its existence is that the rapid development of manufacturing establishments in this country has been such that it has seemed necessary to introduce a military system of organization, with a commanding general, regimental and company officers, noncommissioned officers and then the rank and file. In the great strife to get out work fast and at a minimum profit, the men have too often come to think that they were regarded as less important than the machinery and the shop fixtures. So their unions have fought for uniform wages and uniformly increased pay for the members just as if they really were machines, without individuality. Most employers have spent long hours wrestling with this unfortunate condition and many ambitious employes have bewailed a system which chained them down to the level of a shiftless slouch. This was the condition in the shops of the Atchison, Topeka & Santa Fe Ry. three years ago. The men were discontented and striking, the shop work was expensive, and the road performance of the locomotives left lots to be desired. It was accordingly determined to throw precedent to the winds and get back to the old-fashioned system of making every man's work tell his own story to the higher officials, not letting it sift through all grades of sub-foremen, foremen, and so on. In this way the pay of the efficient men could be increased automatically, as it were, and they would again feel that those toward the top of the ladder were willing to reward their skill and energy. It was decided at the same time to subject the individual tools in the shops to the same sort of scrutiny, and to remodel them if necessary so as to increase the capacity of the shop without adding new equipment. When this work was undertaken under the general direction of Mr. John W. Kendrick, second vice-president, by Mr. Harrington Emerson, counselling engineer, the labor conditions were troublesome. It was uncertain how the men would act if they knew about the proposed plans in advance, and so the methods were introduced slowly and without any talk about them. They have proved very successful. Harmony has been restored, wages materially increased, manufacturing expenses reduced, and locomotive performance improved, and all this with an actual saving to the company. The system is only in partial operation yet, but it is so satisfactory that it is no longer kept a secret, and railway papers have published long articles concerning it.

The basic principle of the system was stated as follows in a pamphlet by Mr. Emerson which was distributed among the men: "Fairness not favoritism, efficiency not drudgery, and individuality not subserviency." This principle has been elaborated into a working system which makes the interests of the company, its officers, its foremen and its workmen identical, an increase and improvement of product at a lower unit cost. Increasing wages is merely one part of the system, for the mechanical improvements due to remodeling machines, standardizing tools and making them in large quantities, and keeping records of all items of expense have been innumerable, although the shops were formerly considered very fair examples of their kind.

The system employed has been termed the individual effort method by Mr. Emerson, and is designed to enable the employer to pay wages higher than the average and at the same time cheapen the cost of output. A careful study is made of the time required to perform each particular piece of work, and from the data gathered in this way a standard time is set in which a skilled workman should be able to turn out the piece regularly. This standard is determined by an expert machinist who actually times every operation, notes the conditions of the tools and the methods of working, and if necessary does the work himself. Before the standard goes into effect it must be checked by the shop superintendent and shop expert and be approved by the superintendent of motive power. If a workman turns out the same pieces at this rate he receives a bonus of 20 per cent. above the regular hourly rate of pay for this class of labor. Extra compensation above the hourly rate is paid even if standard time is not reached, although the bonus percentage decreases steadily to nothing when the work takes time and a half, at which the regular pay, of which the workman is certain, begins. Such an arrangement practically makes the workman his own foreman, so far as working to a schedule is concerned, and if the standard is so unreasonable as to discourage the workman's co-operation the company loses more than the men.

The system was begun at the Topeka shops by first bringing the tools, machinery and shop methods to a high point of efficiency. In this way the hourly rate of fixed charges against each machine was also determined, and it was thus possible to ascertain the profit due to any increase in its production during a given period. When these data were collected, the bonus system was gradually introduced until all the work in the erecting shop, 80 per cent. in one machine shop and 50 per cent. in another, 70 per cent. in the brass department, 75 per cent. in the smith shop 50 per cent. in the air pump and tinsmith's department, and 5 per cent. in the toolroom have been brought under it. It has been made to apply to foremen as well as machinists, and is now being extended as rapidly as practicable to all the shops of the company.

One of the most interesting features of the system is the great variety of information it affords. It will give in a remarkably short time the total number of hours worked by all men during a month, or the pay roll of each group of workmen, or the total payroll, or the amount due to each man, or the total machine earnings in each group, or the total machine earnings, or the hours worked by all machines or by each machine, or the number of different jobs done by any man, or the number of men doing the same machine job, or the number of different jobs done by a machine, or the number of machines doing the same job, or the different kinds of charges against any particular job, and so on through a long list of possible questions. By any ordinary system of cost-keeping, such information could only be obtained by a great number of time-keepers and clerks. By the individual effort system, only seven time-keepers are employed and three of these help on other work. They enter the men's time on special slips, which later go to the recording office, where all the work is done by three clerks, with the help of Hollerith machines like those employed in the Census Bureau. The information on the time slips is punched on record cards, and after that the whole system of analyzing the data is mechanical.

The great success of this work in the shops of the Atchison, Topeka & Santa Fe Railway Co. has made it the Mecca of industrial managers who are seeking to solve the labor problem. The system is not applicable to any kind of job work, where the same operations are performed but a few times, but in regular manufacturing operations it certainly presents marked advantages. It puts on file at headquarters the record of every man and every tool to which the system can be applied, and likewise furnishes a great amount of accurate information that is supplied by no other system. It is comparatively inexpensive, it clears away the haze of uncertainty concerning what each tool is good for, and it furnishes data that help in determining where improvements in tools or in methods of operation can be made. Finally it helps the men make more money, and it helps the company turn out more work at less expense. It is so attractive that The Engineering Record suggests to its readers engaged in manufacturing the advisability of looking into it pretty thoroughly.

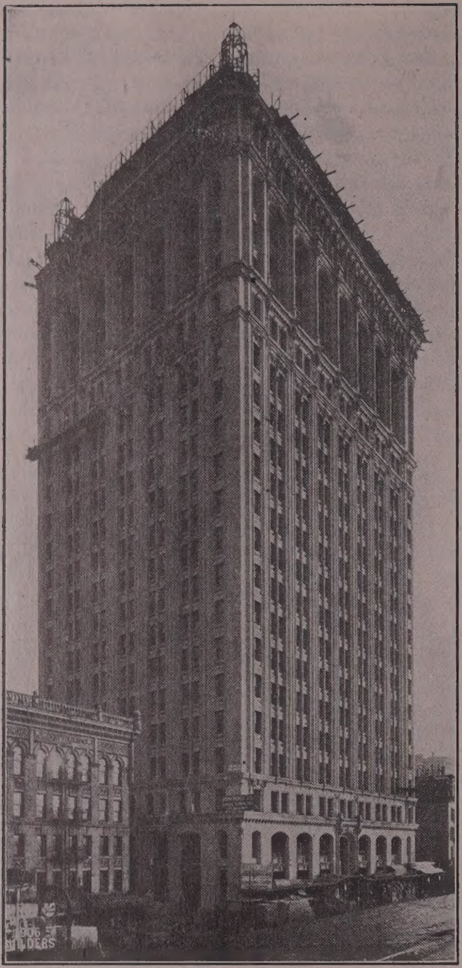
Notes and Comments.

THE UNITED ENGINEERING BUILDING will become the headquarters on Jan. 1 of the American Society of Mechanical Engineers and the American Institute of Mining Engineers, which will both take possession of their new homes on that day. The office address will be 29 West 39th St., New York, easily remembered on account of the numerical peculiarity.

FAST TUNNELING WITH SHIELDS has been done on the twin tubes of the Hudson & Manhattan R. R. from Jersey City to the lower part of Manhattan. The south shield was pushed ahead through the river silt at the rate of 296 ft. in seven days, and on Aug. 13 it was advanced 72 ft. The work is now in rock, and is progressing at the rate of 2 to 3 ft. a day, no attempt being made to go faster, as the tunnel would be finished before the terminal in Manhattan was ready for use.

THE VALUE OF THE PUBLIC LIBRARY as an aid to industrial betterment has been appreciated for some time past in engineering circles, and although the efficiency with which many such libraries are administered is not of the highest usefulness to the engineer himself when engaging in a search upon specialized topics, there is no question of the general helpfulness of such institutions in stimulating the progress of the rank and file of the industrial army. Until recently it has been necessary for the workman to seek the library before he could avail himself of its benefits, but there is a tendency at the present time to bring the library to the worker, which ought to be most productive of good. Since July, 1905, for example, the Lynn, Mass., Public Library has had a deposit station at the works of the General Electric Co., and a large number of employees have availed themselves of the opportunity to secure books of a more or less technical character. The best publications in the electrical and shoe and leather industries have been added, both for reference and circulation. At Proctor, Vermont, the Vermont Marble Co. helps to maintain a library which is used largely by its employees, and there is an increasing demand here for technical books. Various engineering and banking firms maintain highly specialized libraries for the service of their employees, in the belief that those collections of indexed material form tools of real value in the prosecution of the work which comes to hand. In the light of the experience thus far gained, it is safe to anticipate a wide extension of the library movement in industrial works in the near future.

SEWAGE DISPOSAL IN NEW YORK BAY and the waters tributary to it is now attracting a great deal of attention, and numerous suggestions from amateur and regular engineers regarding the subject are now appearing in the New York and New Jersey newspapers. The attention directed to this problem is gratifying, because it will become a most serious one in the course of twenty-five years, and now is the time to begin its study. Very few people appreciate that, at present, any general remedies are outside the boundary of real technical study because the basic data for such a discussion are almost wholly lacking. No physician will prescribe for a patient until the latter's complaints have been made the subject of a diagnosis. The more serious the complaint, the greater skill demanded in the diagnosis. In the same way, such a complicated problem as the disposal of the sewage of the great New York and New Jersey districts tributary to the Bay and Harbor of New York demands the careful examination of present conditions and prolonged study of future development. Construction based on less extensive research will lay a tremendous burden of reconstruction on the next generation. It is necessary to look ahead to the future sewage disposal of places as far west as Morristown in New Jersey, as far north as the whole of Westchester County, as far south as the southern end of Staten Island, and as far east as Flushing and Far Rockaway; in fact, it is possible that such a boundary must be pushed outward before the metropolitan sewerage district is entirely encompassed. The present problem is to study all the conditions of this great district. This cannot be done without an expenditure of time and money for which somebody must pay, and the thing to be done just now is to secure $100,000 for a real investigation and place the work in the hands of the most eminent specialists. It is useless to expect any appropriation that amounts to anything from the legislatures of the two States, and it is out of the question to expect the City of New York to furnish more than a small proportion of the necessary funds. The conclusion seems self-evident that the money for such an investigation as is absolutely necessary for any satisfactory study of the problem must be raised largely by private parties. The question of sewage disposal for this great territory is not one of loading the Bay and its tributary waters with all the sewage they will hold without causing offense, for such a course will inevitably bring about nuisance on account of the impracticability of keeping the sewage of widely separated communities in such a condition that this delicate adjustment is constantly maintained. The problem is rather one of obtaining the best practicable results, and its solution may possibly mean the discharge of crude sewage from some places and the treatment of the sewage of other places. The only way that justice can be done to all places is to consider the problem as a whole, in the light of equity and sound sanitary principles.



The West Street Building, New York.

The Substructure of the West Street Building, New York.

The West Street Building at Cedar and West Sts., New York, is a twenty-three-story steel cage office building occupying an irregular site about 160x120 ft. in extreme dimensions, with the West St. front parallel to and about 300 ft. distant from the bulkhead line of the North River. The site was previously occupied by several five-story brick warehouse buildings, some of them built sixty years or more ago. These had basements about 8 ft. deep below the curb, and their walls were seated on timber footings, some of which were made of pairs of 12x22-in. timbers as much as 60 ft. long, laid close together flatways on a grillage of 4-in. transverse planks about 5 ft. long. The planks were laid on the surface of the earth, mud, and fill at a depth of about 12 ft. below the curb or 1 ft. above mean low-water level.

The soil here was of a heterogeneous character, with filled material overlying fine silt and mud down to a minimum depth of 20 ft. below the curb, beyond which fine hard sand reached to the solid rock or hardpan at an average depth of 50 ft. below the curb. Near the West St. front of the building, the mud and silt were much deeper than in the rear of the lot and were very soft. As the distance from the river increased, the depth of the mud decreased and the consistency of it and of the silt became much harder and more satisfactory, being firm and solid so that it could be easily cut and handled as excavated. It was, however, composed of very fine particles which easily ran under the action of water and formed a very thin, soupy mixture if exposed to moisture.

The old timber footings were found in perfect condition, the timber being apparently as sound and good as new. A visitor to the work asserted that he had built some of these footings about 60 years ago. The footings were carried over a rock-filled timber crib, evidently part of a former bulkhead which crossed the lot nearly coincident with the longitudinal axis. It was about 25 ft. wide and 20 ft. high, the upper surface being about 12 ft. below the curb. The timber in it was sound and good and on most of it the bark remained intact.

After the removal of the old buildings, the lot was enclosed by ordinary 3-in. sheet piling driven outside the basement retaining or area walls and the general excavation was carried down nearly to the ground-water level without difficulty, where it was temporarily stopped to avoid the annoyance of working in the soft, wet material that would be developed at a little greater depth. In removing the old cellar floors, it was noted that considerable trouble had evidently been found in making them water-tight; as one floor proved permeable, it was reinforced by another one on top of it, until in several cases there were a number of successive thicknesses of concrete, planks and waterproofing material.

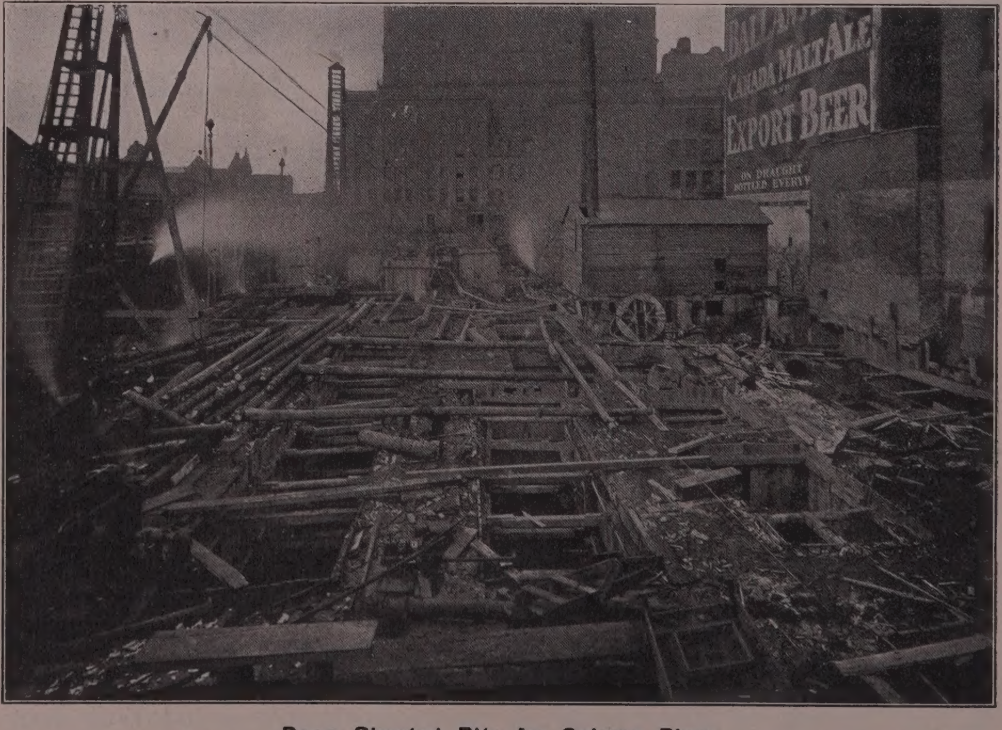
One of the first things was to provide for the sidewalk traffic along the West St. front of the building, which was done by building a foot bridge over the space later occupied by the sidewalk vault. The bridge floor was laid on transverse joints carried by two continuous lines of 12x12-in. longitudinal timbers about 6 ft. apart, which were in turn supported on 12x12-in. transverse timbers 20 ft. long and 15 ft. apart. These timbers were long enough so that their outer ends were supported on timber cribbing seated on the street basement beyond the edge of the excavation. The inner ends were at first similarly supported on blocking, which was gradually changed as the excavation undermined it, and was replaced by vertical shores carrying the beams.

Owing to the deposit of silt and mud and the close proximity of the North River, it was anticipated that considerable difficulty would be encountered in keeping the excavation free from water. This was averted and all of the foundation pits were made in open excavation lined with ordinary sheet-pile coffer dams made with square-edge 3-in. planks moderately braced. It was thought that the fine silt was so easily carried by the water that it followed all the interstices in the sand and filled them, thus approximately sealing them, and reducing to a comparatively small amount the flow of water, which was successfully handled by a sufficient number of ordinary plunger steam pumps.

Except the two intermediate longitudinal rows which encountered the ancient crib, the piers were built in pits excavated from 3½ to 13 ft. below the basement floor, or about 12 ft. farther below low tide. In them clusters of piles were driven to complete refusal of such a character that it was positively designated by the contractors as solid rock at all points. This was verified subsequently when cores were taken out in boring for plunger elevators over 300 ft. through solid rock. Toward the river side of the lot the driving was so easy that it was considered that the tops of the piles would be benefited by more lateral support than the earth and mud would give them. In these places the pits were excavated to a depth of about 20 ft. below the curb; about 5 ft. of sand was rammed in around the piles and then a layer of 1:2:6 cinder concrete 5 ft. thick was deposited on the sand and thoroughly rammed between the piles, enclosing them with a substance so porous that it insured the penetration of moisture to preserve the piles from decay. On the cinder concrete, the regular footing of 1:2½:5 broken stone concrete was laid to a level about 6 in. above the tops of the piles, all the latter being cut off far below water-level. Where the ground was sufficiently hard and firm the sand and cinder concrete filling was omitted.

The two longitudinal rows of piers nearest the center line of the building encountered the old crib and the excavations for them were successively carried through it, but at a considerable expense of time and labor. The full-size excavation for each of these piers was made to a total depth of nearly 40 ft. below the curb by cutting through the crib timbers and carefully removing them and the stone filling. The pits were lined as fast as sunk by 4-in. vertical sheet piles. The latter, however, corresponded more nearly to sheeting than to piles, since the external pressure on them was small and they were easily driven by hand. The first length were ordinary 16-ft. planks, and after the excavation was carried below them they were successively removed singly and replaced by longer planks, which were finally driven down to a point just below the lowest timbers of the old crib, where they terminated in hard fine sand.

Provision is made for a water-tight basement



Deep Sheeted Pits for Column Piers.

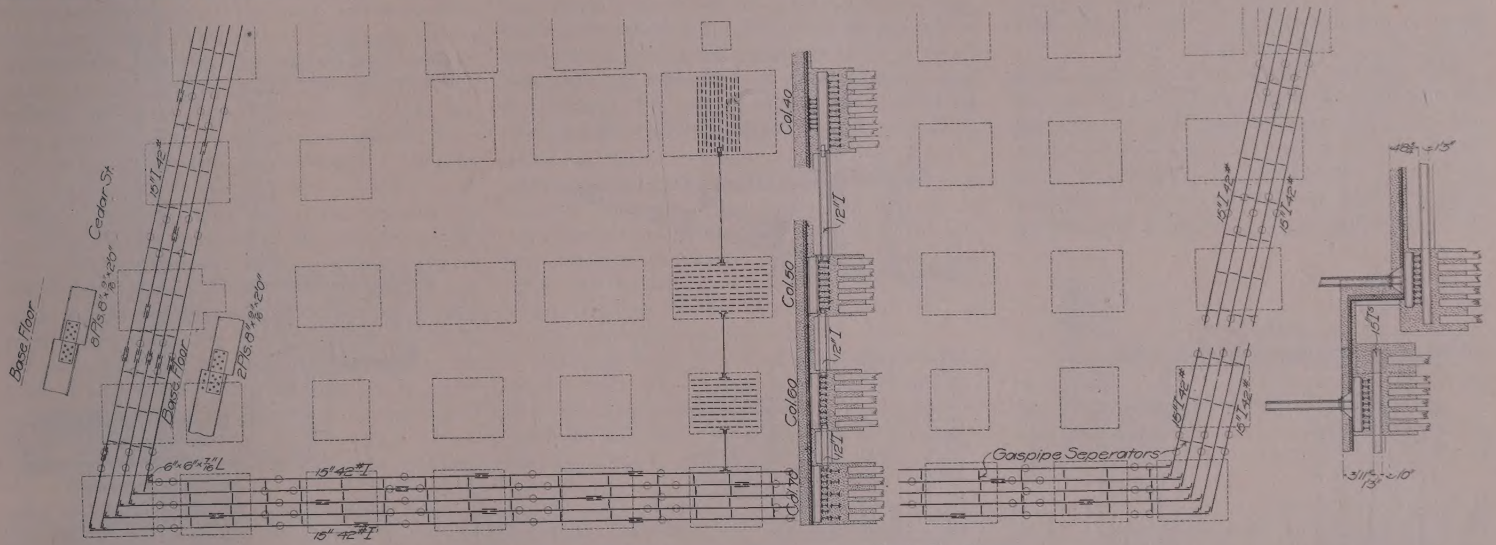
to exclude the ground water so thoroughly as to preclude the necessity of regular pumping, although a sump and connections are provided by which the water can be removed in case of any accidental leakage. This feature of the construction necessitated provision to resist an upward vertical pressure on the entire surface of the basement floor due to the hydrostatic head of the ground water. It was at first intended to resist this pressure by means of steel reinforcement in a concrete floor of moderate thickness. As the work progressed, it became evident that the steel superstructure might be completed before the basement was finished, and it was determined to supersede the reinforced concrete by a greater mass of concrete without reinforcement, thick enough to afford the required strength and also heavy enough to counterbalance the upward pressure by its own weight.

This was effected by covering the entire area of the building with a monolithic mass of concrete about 6 ft. thick extending up to the cellar floor from a level a few inches above the tops of the piles. This concrete was placed in small sections and was made with a lower 6-in. layer on which the special waterproofing described in The Engineering Record of May 12, 1906, was carefully laid to break joints across adjacent sections, the edges of successive areas being dove-tailed to each other as described in the previous article. The waterproofing was carried up around the column piers and under the plates of sheet lead which were set on the grillages to receive the cast-iron column bases. The flashing was dove-tailed to the horizontal portions and the waterproofing on the vertical retaining walls was dove-tailed to the flashing from the floor water-proofing.

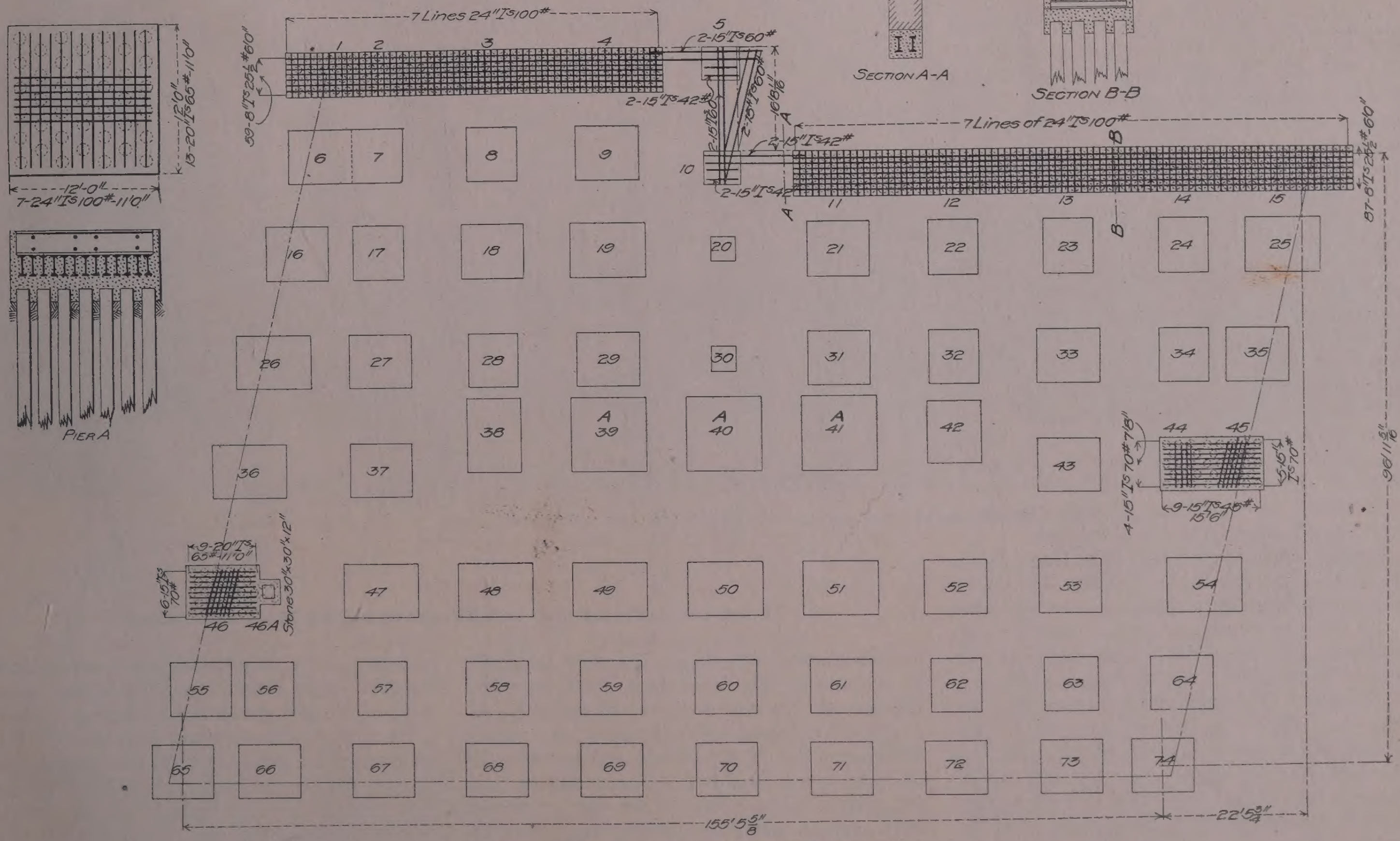
Above the waterproofing, the remainder of the concrete slab, about 5 ft. in thickness, was deposited in the usual way, care being taken to bond it thoroughly together at points where successive sections joined each other. This concrete differed from that in the piers in that, although the proportions were the same, it was made with washed gravel instead of broken stone. All concrete was made with the Trowel brand of Portland cement, was mixed by hand, and was distributed over the work by wheelbarrows.

As it had been noticed that there is a tendency for the buildings in this locality to settle a little out of plumb, with the front walls leaning outward toward the river, special provision was made to reinforce the foundations of this building in such a manner as to insure the united action of the piers. To this end a series of 15-in. horizontal I-beams was arranged to form a continuous grillage extending the full length of the West St. front and carried back from the ends of this front in the planes of the side walls.

The grillage was made of five lines of 15-in., 42-lb. I-beams of convenient lengths, bedded in the concrete 12 in. clear above the tops of the



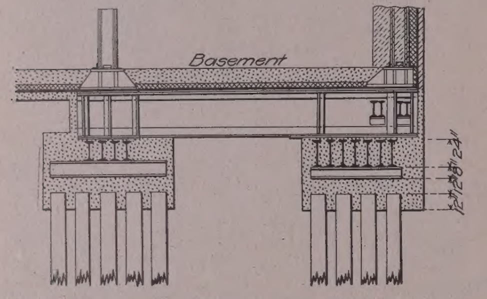
Continuous Distribution Beams in Wall Footings.



Foundation Plan and Wall Grillages.

piles. They were in stock lengths, spaced about 18 in. apart by gas pipe separators 6 ft. apart, and were made continuous from end to end by splicing the joints in adjacent beams. At the intersections of the front and side walls, the grillage beams were rigidly connected by 6x6x 7-16-in. angles, field-riveted to the web of one beam and shop-riveted to the web of the other beam. The arrangement of the beams was such that the end of one beam projected beyond the intersection and afforded connections for each beam in one line with two beams in the intersecting line, as indicated by the detail.

Although the concrete in which these beams are embedded has continuous bearing on the earth and sand, it is assumed that they are supported entirely by the groups of piles under the centers of the wall columns and the additional piles supplied here between piers, and that they distribute the superimposed loads to all piles, thus preventing any irregularity of settlement. The short longitudinal grillage beams are bedded in the concrete just above the 15-in. beams and independent of them, like the regular grillages of the intermediate piers. Besides the long continuous beams, a set of 12-in. horizontal I-beam anchors run from the middle of the West St. front to three of the intermediate foundation piers and are securely riveted to the grillages, thus forming a solid tie.



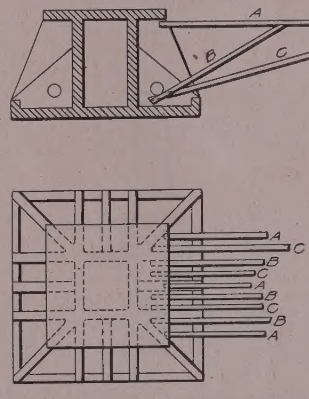
Elevation of Cantilever for Wall Column.

The superstructure of the building is carried on 74 main columns, of which fourteen are supported on continuous footings in the wall opposite the West St. front. These footings are made with staggered piles about 17 in. apart in four longitudinal rows 12 and 20 in. apart. The tops of the piles are capped with concrete in which there are bedded, 12 in. clear above them, 8-in. transverse I-beams on the center lines of all piles. On these beams are seated seven lines of longitudinal, 24-in., 100-lb. I-beams forming a continuous footing for the wall columns.

The nine columns seated on these long footings are located so close to the building line that it was necessary to support them on cantilever girders in order to secure symmetrical loading on the footings. The inner ends of the cantilevers are carried by the piers in the first intermediate row of columns. The cantilevers are triple plate girders about 18 ft. long and 36 in. in depth. The girders of each set are spaced 16¼ in. apart and are connected by shop-riveted top and bottom flange cover plates at both ends, but not continuous for the full length of the girders. The materials in the girders vary according to the loads; the lightest girders have 36x7-16-in. web plates, reinforced by 36x5-16-in. half-length pieces, 42x ⅝-in. flange cover plates and 6x4x15-16-in. flange angles.

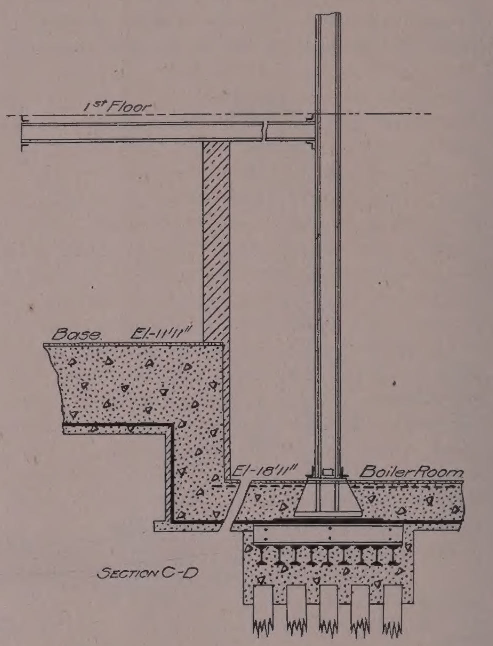
As this face of the building is offset the footing is made in two separate lengths in parallel lines. The end piers in these lines near the center of the wall are detached from the footings and are connected by pairs of transverse 15-in. I-beams, as indicated in the plan, which serve as cantilever girders for the eccentric support of wall column 5. Intermediate columns 46 and 46A are both supported on a single pier, as are columns 44 and 45.

The remaining 50 intermediate columns are each supported on independent piers, all consisting of clusters of piles in staggered rows, capped with concrete and two tiers of grillage beams, except in the case of pier H, where the load was so great that a third set of grillage beams was introduced. The dimensions of the piers vary according to their loads from 4 ft. to 12 ft. square, the numbers of piles from 4 to 25, each of them being calculated for a maximum load of 12 tons, the assumption being that all of them have solid bearing on rock and are supported laterally at the bottom by the hard sand and at the top by the continuous horizontal slab of concrete below the cellar floor. The piers 4 ft. and 6 ft. wide have light loads from short secondary columns and are not provided with grillages. All of the others have a lower tier of 12, 15 or 20-in. I-beams on the column centers and an upper tier of transverse 15-in. I-beams distributing on them the column loads, except in the case of pier A, 12 ft. square, where the distributing girders are 24-in., 100-lb. I-beams.

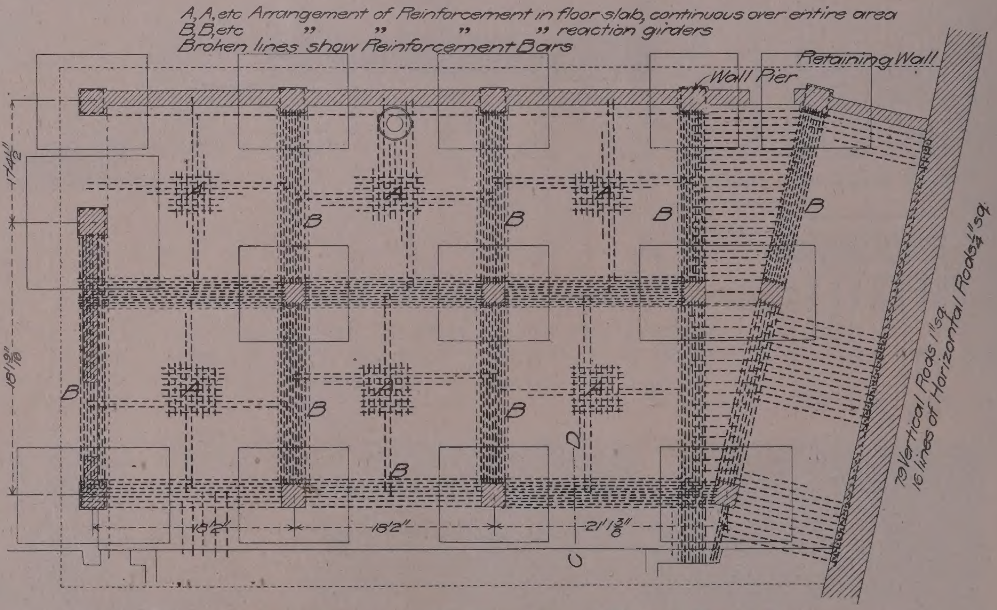


Connection of Reinforcement Bars in Cellar Floor to Column Pedestal.

The floor of the 36x75-ft. boiler room covers six main panels and is 7 ft. below the basement floor. This increased depth involved so much more upward hydrostatic pressure that the floor was made of a slab of concrete 2½ ft. thick, including the granolithic surface, the waterproofing and the bottom layer, reinforced with ⅝-in. Ransome bars close to the upper surface, arranged as indicated in the general plan. Sets of horizontal 1-in. rods were placed in the concrete in the planes of the column rows, virtually making girders which divide the floor area into 18-ft. panels and transmit the loads from them directly to the column bases, which receive the upward reaction. The reinforcement of the slabs between these girders consists, as shown, of ⅝-in. longitudinal and transverse rods 6 in. apart over the whole area. The ends of the 1-in. rods take bearing on the under sides of the top flanges of the column pedestals or else are bent down as shown in the detail to engage bolts provided in the vertical webs of the pedestal to receive them.



Depressed Floor in Boiler Room.


A, A, etc Arrangement of Reinforcement in floor slab, continuous over entire area
B, B, etc " " " " reaction girders
Broken lines show Reinforcement Bars
Retaining Wall
Wall Pier
17'4½"
18'1⅛"
A
A
A
A
A
A
B
B
B
B
B
B
B
B
B
D
C
18'2"
18'2"
21'1⅜"
79 Vertical Rods 1" sq.
16 lines of Horizontal Rods 1" sq.

Reinforcement for Upward Pressure on Boiler Room Floor.

As soon as the piers and footings were ready to receive the superstructure, the columns were set and the general excavation between the piers was carried on at convenience during the erection of the superstructure. Small portions of the area were excavated to subgrade for the cellar and boiler room floors, and concrete was laid in successive portions carefully bonded together. Finally the full depth excavation was carried to the lot lines and the reinforced concrete retaining walls of ordinary construction were put in. As much of this excavation was below water level, the mud and silt became very soft and the work was difficult and disagreeable, but was slowly accomplished by hand with persistent effort and constant pumping from sumps. The difficulties were considerably increased by trouble with the adjacent street sewers, which were old and leaky at best and several times burst and flooded the pit.

Although the cellar floor and walls are waterproofed to completely exclude all ground water, it was desirable to reduce the exterior pressure during construction, and a number of open drains were laid below the concrete floor, discharging into a deep central sump fitted with a 6-in. vertical cast-iron pipe having two flanges on the upper end, the lower one built into the concrete of the finished cellar floor and the upper one flush with the floor surface. This pipe was left open during construction and virtually served as a well in which the suction pipe of the drainage pump was inserted and enabled the water to be pumped out, thus preventing the development of upward pressure on the floor. After the building is completed, it is intended to connect a valve with the upper flange of the pipe and close it, thus allowing the sump to fill and trusting in the strength of the floor and the efficiency of the waterproofing to exclude the water. Afterwards, however, if any leaks should develop or other necessity should arise for it, the pump connections can be made, the valve opened and the water drained from the sump as before. This is considered as an emergency provision and it is not expected that it will be ordinarily required.

Mr. Cass Gilbert is the architect of the building, Mr. Gunvald Aus is the consulting engineer, and the general contract was awarded to the John Peirce Co., Mr. Emil Diebitsch, vice-president. The steel work was fabricated and erected by Milliken Bros., and John Monks & Sons were the subcontractors for the pile-driving excavation and concrete up to subgrade for the cellar floor.

The Bridge Type of Movable Dam will be used on the lower Mohawk River section of the New York State Barge Canal. It has been employed successfully on the Moldau River in Bohemia and will probably be used on the Seine River in France. In the annual report of State Engineer Van Alstyne the reason given for adopting the type is that it permits the control of water surfaces to a much greater degree than would be possible with a fixed dam and permits the restoration of the river to its natural condition when the canal is not in use. Moreover, in time of flood, the silt, debris and detritus are washed downstream instead of accumulating in the pool above the dam, and a considerable amount of money otherwise required for dredging will probably be saved.

The Pittsburgh Filtration Plant.—IV.

Contractor's Plant and Methods.—The contractor has installed a very extensive and complete plant with which the construction of all sections of the work has been carried on simultaneously. The topography and location of the site and the arrangement of the various parts of the filter plant have made this simultaneous construction work most readily followed. The gravel and sand, which form the bed of the Allegheny River in front of the site, are well adapted for concrete materials and for use in the filters. Large docks for handling these materials have been erected on the river bank in front of the site and plant has been installed to transport the materials from these docks to different places on the work where it is to be used. The large amount of lumber, pipe, machinery, cement and other materials and supplies required in the construction are practically all brought to storage areas and houses along a switch from the West Penn Division of the Pennsylvania R. R., the tracks of which extend through the site.

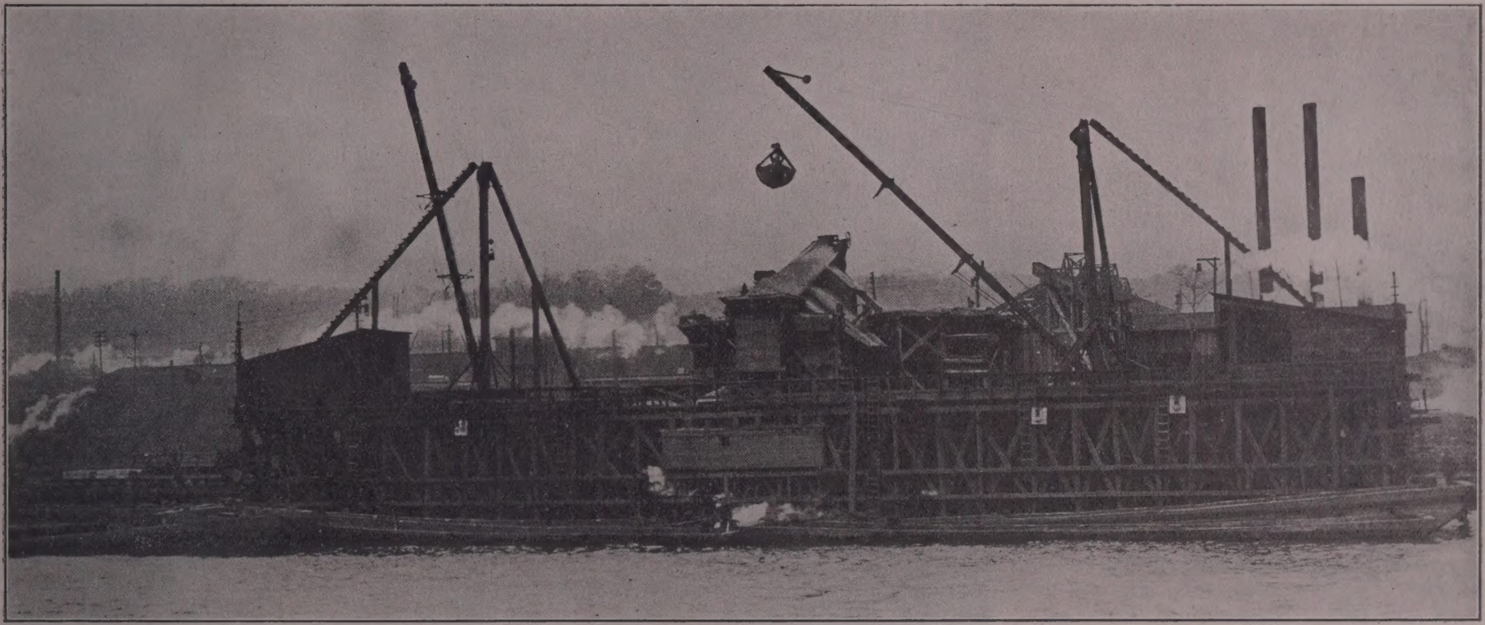
Although work has been in progress on all parts of the plant at the same time, it will perhaps be more clear to follow the equipment and methods that have been employed in constructing the various structures and pipe lines from the intake through the pumping station to the sedimentation basins, and then to and through the filters, the filtered-water reservoir and across the river to the Brilliant pumping station.

The natural ground surface in the vicinity of the site of the intake was not much above the ordinary stages of the river, and during high water was completely flooded. The intake is built in an excavation in the natural bank that was carried down 18 ft. below low water in the river, into the freely flowing gravel that underlies the site. An embankment is being built around the intake on the river side to 2 ft. above the ordinary flood level, and on the slope of this embankment is laid the heavy concrete-block revetment mentioned in a previous article.

The excavation for the intake was made in a cofferdam about 100 ft. x 200 ft. in plan, which was carried 10 ft. above low water and had one side formed by the bank of the river. This cofferdam consists of three rows of 2x10-in. sheet piling, with an earthen embankment on each side of it. The piling was driven well into the gravel of the river bed with a floating driver. The embankment was made with material from the bed of the river that was handled by clam-shell buckets on derricks mounted on scows. Part of it was also made with material from excavations on the shore, which material was hauled out in dump cars on a narrow-gauge track on a trestle built over the row of sheet piling. The slope on the outside of the embankment was made 1 on 2, and that on the inside 1 on 2½. The cofferdam stood for over a year without being washed out in any place, although it was filled by floods on several occasions.

The excavation in the cofferdam was largely made by hand and was handled out of the pit by two guyed derricks in 1¼-yd buckets. These buckets were loaded on narrow-gauge flat-cars and hauled out to make the embankment around the intake and to a spoil bank. Part of the excavation was made with a drag scoop bucket handled by a derrick with the addition of a snatch block attached to one of the piles of the cofferdam.

The nature of the gravel into which the excavation was carried is such that an unusually large amount of water entered the excavation. The level of this water had to be kept below the form work for the concrete and also below the level of the latter while it was being laid. A sump was made in one corner of the excavation and all of the seepage drained to it. Three or four 12-in. centrifugal pumps were kept constantly in operation removing the water from this sump while work in the cofferdam was in progress.



Contractor's Main Dock at River for Handling Concrete and Filter Gravel and Sand.

The concrete for the intake, of which about 2,500 cu. yd. are required, is delivered in bottom-dump buckets on narrow-gauge flat cars from a mixing plant several hundred feet downstream on the bank of the river. All of it has been laid in the dry, that in the lower part of the footings being placed on canvas laid on the bottom of the excavation to hold the concrete in place until it could attain a permanent set.

The trench for the 124-in. concrete conduit leading from the intake to the pumping station was on the average about 12 ft. wide and from 15 to 25 ft. deep. The lower part of it was about 12 ft. below low water in the river and in the free-flowing gravel so that much water was encountered, three 12-in. centrifugal pumps being required most of the time to keep the water down. The material above the gravel was also of such nature that the trench had to be sheeted heavily throughout its length.

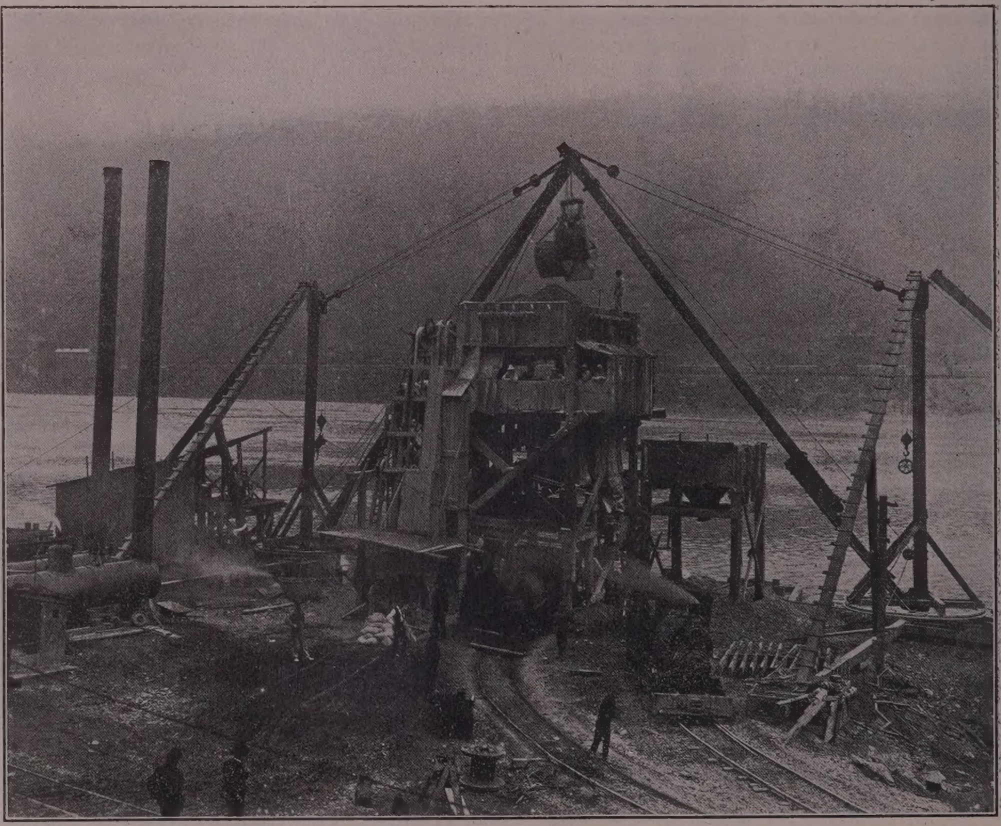
The site of the pumping station was at about the level of ordinary floods and is underlaid by the same free-flowing gravel encountered in the construction of the intake. About 14,000 cu. yd. of concrete are required in the construction of the pumping station, most of which is in footings and engine settings. The concrete footings for the walls of the buildings and the settings of the various engines and pumps were built on the gravel in excavations carried down through the material overlying the latter. The settings for the large raw-water pumps in the pit along the north side of the building are necessarily very heavy and in them is the 100-in. suction trunk for these pumps. These settings and the suction trunk were built in a heavily sheeted pit. A narrow-gauge track was extended into the site of the engine-room, parallel with this pit, and on it most of the excavated material was hauled to a dump in buckets on flat cars, the excavation being made by hand and the buckets placed on the cars by guyed derricks. The concrete was brought in over this track in bottom-dump buckets, which were handled to place by the guyed derricks which were placed at commanding points.

The 96-in. riser main leading from the pumping station to the central gate chamber at the sedimentation basins is all in trench up to the embankment of the eastern basin. The trench for this main was from 12 to 13 ft. wide and had a maximum depth of 25 ft. The sandy soil through which some of the trench was made required close sheeting to hold the sides of the trench in place. The pipe was laid in sections generally 30 ft. long and field joints were made between these sections. The pipe was laid up to the embankment of the basin and then the concrete in which it is enclosed was placed and the trench back-filled. Vertical curves in the main bring it up above the natural ground surface at the embankment so that it is in the latter from the point where it joins the embankment to the gate house. Since in this portion of the main leaks would be of serious consequence, after the pipe had been laid the concrete in which it is enclosed was omitted around the field joints in the pipe until those joints could be tested under pressure for leakage.

The sedimentation basins are mostly all in excavation, varying from a few inches to several feet in depth, although over a part of their sites some shallow fills had to be made to bring the clay sub-soil to grade after the top soil had been stripped. The total excavation for the three basins amounted to approximately 150,000 cu. yd. The top soil was stripped and is stored in piles out of the way until it can be utilized in finishing the slopes of the embankment and in finishing the fill over the filters. The shallow excavation for the receiving and the western basins was made with two New Era grading machines working in connection with 2-yd., four-wheeled, bottom-dump wagons. These graders were drawn part of the time with horses and the remainder with traction engines, and had a combined capacity in ten hours of about 2,000 yd. The bottom-dump wagons hauled the sandy clay that was taken out into the embankments, where it was deposited in 6-in. layers and rolled with steam road rollers or with traction engines. The deeper excavation in these two basins was made with two 70-ton Marion steam shovels. The material was hauled from these shovels to spoil banks in 3-yd., narrow-gauge dump cars by light locomotives.

The excavation for the eastern sedimentation basin is just being completed. This work was done by a sub-contractor who had a large outfit of mules and wheel scrapers with which practically all of the excavation was made. The clay obtained in the excavation for this basin was nearly all required in the embankments for the latter and was placed in these embankments with the wheel scrapers and rolled with traction engines.

Concrete Mixing Plant for Sedimentation Basins.—The concrete used in lining the basins and in the concrete revetments protecting the inner slopes of their embankments has mostly all been mixed in a central plant near the projected transverse center line of the eastern basin and close to the outer edge of the embankment of the latter. Sand and gravel for the concrete made in this plant are brought to the latter from a dock at the river over a double-track narrow-gauge tramway. This tramway has a total length of 1,900 ft. and passes through the subway under the four tracks of the Pennsylvania R. R. and the highway along the latter. The dock at the river is equipped with a stiff-leg derrick, the boom of which is swung by a bull wheel. A 1¼-yd. Hayward clam-shell bucket on the derrick unloads the gravel and sand from the scows in which it is brought to the dock and places them in two hopper-bottom bins, one for sand and the other for gravel, elevated above the two tramway tracks which are on a trestle above high water at the dock.


Mixer Plant Furnishing Concrete for Filtered Water Reservoir.

An endless cable is operated up one tramway track to the mixer plant and back on the other to the engine near the dock which drives it. This cable has a total length of 3,800 ft., and hauls the loaded narrow-gauge cars up the tramway to the mixer plant and brings them back again, each car being equipped with a cable grip. The tramway tracks have maximum grades of about 20 per cent. and make a 90-deg. turn at the river. The dock and tramway system have a capacity of about 600 cu. yd. a day. The tramway system was built by the Trenton Iron Co., of Trenton, N. J.

The concrete mixing plant to which the two tramway tracks lead has two elevated storage bins, one for sand and the other for gravel. Each of these bins has a capacity of 60 cu. yd., one of them being on each side of the longitudinal center line of the structure that carries them. The two tramway tracks extend longitudinally over the tops of these bins, one over each bin, at about 23 ft. above the ground. The gravel is dumped into the bin for it from the track on one side and the sand into the bin on the other side from the other track, a switch connecting the two tracks. A small elevated storage shed for cement is also provided at the level of the tops of the bins, a bag elevator taking the cement up to this level from wagons at the surface.

Two Foote concrete mixers, each with a working capacity of about 125 cu. yd. per 10-hr. day, are placed under the elevated storage bins. The three feeding hoppers on each of these mixers, one for cement, a second for sand and a third for gravel, are each supplied through connections with the storage bins. The mixers each discharge into three yard side-dump cars on two narrow-gauge tracks that are run under the storage bins. Light locomotives haul these cars out to the point where concrete laying is in progress on the basins.

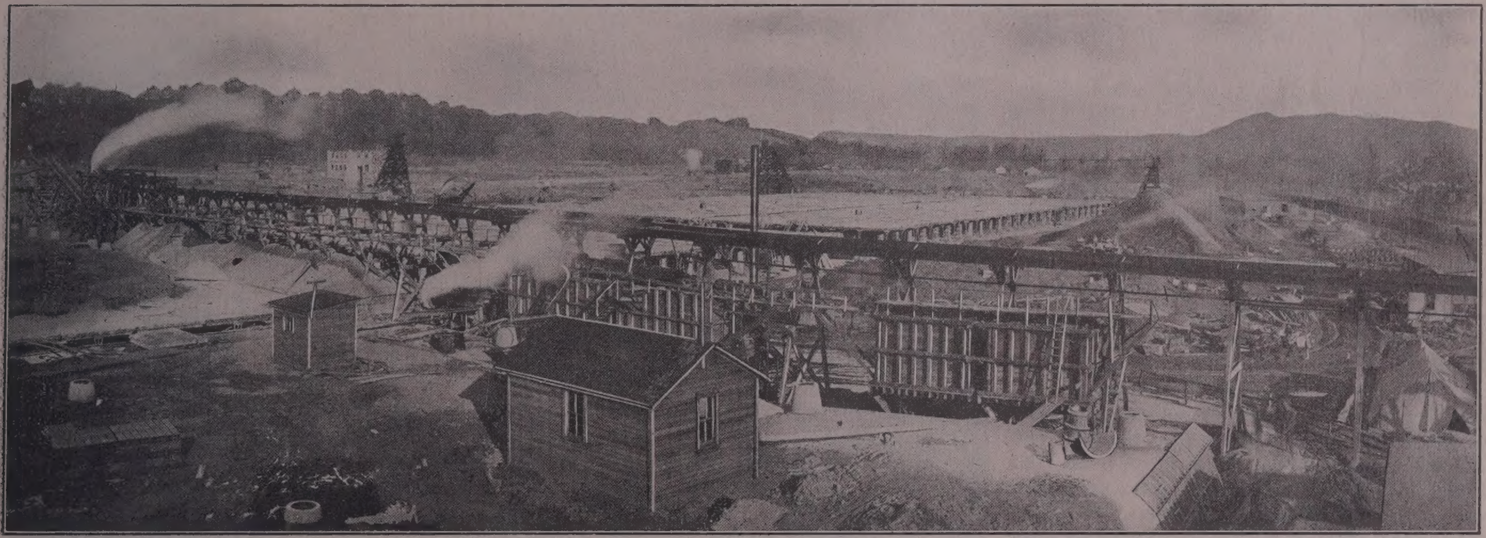
Tracks were laid on the bottom of the large basin to the west to supply concrete for the lining of the bottom. The concrete was dumped directly in place from cars on these tracks, the latter being shifted as the work progressed. A track was also laid around the basin after the embankment had been more or less completed. On this track the concrete for the lining of the slopes, the gravel between this lining and the revetment, and the concrete for the latter, were delivered. The inlet and outlet conduits for this basin were also built with concrete delivered on the track around the basin.

The concrete for the lining of the bottom of the receiving basin was mixed in a portable Foote mixer and wheeled to place. The concrete for the lining and revetment on the slope of one embankment of this basin was delivered from a track on the embankment, and that for the other slope will be delivered in the same manner. The concrete for the inlet conduit of the receiving basin was mixed in a portable Foote mixer which was placed on top of the conduit and was hauled forward as the work progressed.

The large reinforced-concrete conduits that extend along in the embankments of each of the large basins, from the outlet ends of the latter to the central gate chamber, were built in alternate sections, 30 to 32 ft. in length. Two alternate sections were built and then the intervening section completed, the concrete of the sections being keyed together at the ends. The forms for these conduits were made collapsible and were used repeatedly, being taken down and carried forward in the completed conduit from section to section. The forms for each section were erected on four small concrete pedestals which were set accurately to grade and to alignment.

The forms and steel reinforcement for each section could be set in from one and a half to two days by 12 men. The concrete was made in portable Foote mixers set up on the embankment beside the work. The materials for the concrete were delivered to the mixers in wagons. A 32-ft. section of the 7 or 8-ft. conduit would be concreted with one of these mixers in from 5 to 8 hours.

Excavation for Filters.—The excavation for the filters averaged about 3 ft. in depth and varied from a few inches as a minimum to 10 ft. as a maximum, the total excavation amounting to 550,000 cu. yd. The excavation is practically all in sandy clay soil that was covered by a stratum of top soil averaging about 2 ft. thick. The top soil has generally been removed with wheel scrapers and the New Era grading machines and placed in storage piles. Most of the remainder of the excavation has been made with traction Vulcan steam shovels. These shovels have extra high booms, which permit wagons on the bank to be loaded by them, this arrangement avoiding all wagon tracks in the excavation. The latter is carried down not closer than 3 in. to the finished sub-grade of the filter floors. The remainder of the excavation is done by hand in order to present an undisturbed surface on which the concrete of the filter floors may be laid. The clay from the filter excavation has been stored in piles and used in filling over the filters as the latter were completed. Some of the clay was also used in the embankments of the sedimentation basins.



Monorail Tramway from Dock at River to Central Mixer Plant.

Concrete Mixing Plant for Filters.—The concrete for the filters is all supplied from a central mixer plant containing two Hains gravity mixers, with a combined capacity of 800 cu. yd. in 10 hr. This plant is placed in the space that will be occupied by the drive over the Allegheny City water main and is approximately at the center of the area covered by the filters. It is connected by a monorail tramway system for conveying sand and gravel with equipment on a dock at the river, which has a capacity for handling 1,200 cu. yd. of material a day from scows in the river to the conveying system. This dock consists of a large platform carried on piles well up above flood level in the river. Two stiff-leg derricks, equipped with 1¼-yd. Hayward clam-shell buckets, are mounted on the river side of the dock and handle the gravel and sand from scows in which it is delivered to overhead bins erected on the platform of the dock. Gravel and sand for use in the filters are also handled at this dock, as well as for the central mixing plant, from which concrete for the construction of the filters is supplied. A large amount of gravel for filling is also unloaded at this dock.

The monorail tramway system extending to the central mixing plant from this dock, is carried well above the ground surface on an elevated trestle, and has a total length of 1,200 ft. It consists of one track leading from the dock to storage piles at the mixer plant, and another track leading back to the dock from these storage piles. One of these tracks is on cantilever arms on each side of the trestle carrying the system and the two are connected at the ends so they form a continuous loop. On these tracks are suspended 1¼-yd. buckets which are hauled by a continuous cable driven by an engine at the dock. This tramway has a capacity of handling 1,800 cu. yd. of sand and gravel in a 10-hr. day and was built by the Trenton Iron Co., of Trenton, N. J.

The elevated storage bins to which sand and gravel for concrete are delivered at the main dock discharge directly into the buckets on the tramway and are carried in the latter to the storage piles at the end of the tramway at the mixer plant. These storage piles are confined in tight wooden bins placed under the trestle carrying the tramway, and with their floors nearly level with the ground. The bin for sand and the one for gravel are separated by a partition. The former is 40 ft. wide by 50 ft. long in plan and the latter is 40 ft. wide by 175 ft. long, the capacity of the sand bin being 1,000 cu. yd. and of the gravel bin about 1,500 cu. yd.

The central mixer plant is built up just beyond these storage piles, the discharge chutes of the two Hains mixers being high enough above the ground surface to clear light locomotives on a narrow-gauge track laid under each mixer. An elevated supply bin for gravel and one for sand are erected over each of the mixers at sufficient height to provide room for a working platform built around the feeding hoppers of the two mixers.

The sand and gravel is carried from the storage piles at the end of the tramway up to these supply bins by two 22-in. inclined belt conveyors, furnished by the H. W. Caldwell Sons Co., of Chicago. These inclined conveyors are each 135 ft. long and are placed at an angle of 18 deg. with the horizontal. A tunnel is built under the entire length of the sand and gravel storage bins on the ground and on each side of this tunnel is placed a 22-in. horizontal belt conveyor, that delivers to one of the two inclined belt conveyors leading up to the supply bins over the mixers. A longitudinal row of 16 hoppers with under-cut gates is placed in the bottom of the sand and gravel bins directly over the horizontal belts. Materials may thus be fed on these conveyors from the bottom of the storage piles and delivered to the inclined conveyors.

The upper ends of the inclined conveyors are directly over the supply bins for one of the mixers so that gravel and sand may be discharged into either of these bins by them. A horizontal conveyor belt extends from the upper end of each of the inclined conveyors to the bins over the other mixer. A special form of gate, mounted on a truck, is placed under the end of each of the inclined conveyors. This gate is so arranged that sand or gravel may be discharged into the bin provided for either of these materials over the first mixer, or so the inclined conveyor will discharge on the horizontal conveyor leading to the other bins or will discharge partly on these conveyors and partly into the bins directly under their ends. The supply bins over the mixers discharge directly into the charging hoppers of the latter through chutes controlled by under-cut gates.

The cement for the mixers is delivered from storage sheds to the foot of an elevator at the mixer in sacks in small cars hauled by a light locomotive. The cars are hoisted one at a time to the working platform around the charging hoppers of the mixers. The cement is placed in the charging hoppers by hand. The water supply for each mixer is obtained from a measuring box mounted at the side of the supply bins for gravel and sand.

The mixers discharge into 1-yd., bottom-dump Cyclopean and Steubner buckets on flat cars on the narrow-gauge track laid under each of them. These tracks connect with two double-track tramways extending the length of the site of the filters at right angles to the galleries between the latter, and parallel to the site of the drive over the Allegheny City water main. The filters on each side of the site of this drive are spanned by cableways with traveling towers, which handle the buckets of concrete to place. The head towers of these cableways are on tracks placed in the drive site. The tail towers of the cableways spanning the filters on the side of the drive toward the sedimentation basins run on tracks in the bottom of the latter. Three of these cableways are provided, two over the filters on the basin side of the drive and one over the filters on the opposite side. These cableways have spans of 600, 600 and 350 ft. respectively, and have a working capacity of 4.5 tons each.

One of the double-track tramways with which the tracks under the mixers connect, is laid on each side of the tracks carrying the head towers of the cableways. The buckets of concrete can thus be delivered directly to the cableways and then carried by the latter to the point where concrete work is in progress and dumped.

The three filters spanned by a cableway are generally built at the same time, the construction being carried on in longitudinal strips of from two to six bays of arches, depending on the amount of sub-grade that has been prepared. The first 4-in. layer of filter floor is laid in alternate squares about 10.5 ft. on a side, extending in longitudinal strips generally across the three filters, and the intermediate squares are filled in afterward. The second layer of the filter floor is then laid in the same manner, the diagonals of the squares in it being at right angles to those of the squares in the first layer and the squares in the two layers breaking joints 6 in. The forms for the piers carrying the groined arches of the covers and the forms for the latter are next erected and the piers and arches built at the same time. The construction is carried forward in successive strips across three filters in this manner, the strips being bonded together by a key left in the outer edge of each strip as it is finished.

The space occupied by the tracks of the head towers of the cableways and of the two tramways serving these cableways is wider than the space between the filters on both sides of the drive over the 60-in. Allegheny water main, so that three longitudinal bays are omitted on the row of filters next to the drive on the basin side of the latter until the tracks can be removed. These bays and the side wall of the filter are then closed in either with concrete from the cableways or from portable Foote mixers set up on the roof of the complete work. These portable mixers have also been used extensively where sections of arches were left open for any reason after the cableway had passed.

The tracks for the tail towers of the cableways on the bottom of the westerly sedimentation basin were laid on the natural ground, and the concrete lining of the portion of bottom covered by these tracks omitted until the latter could be removed. The cableway furnished a portion of the concrete for this finishing work on the lining of the basin bottom.

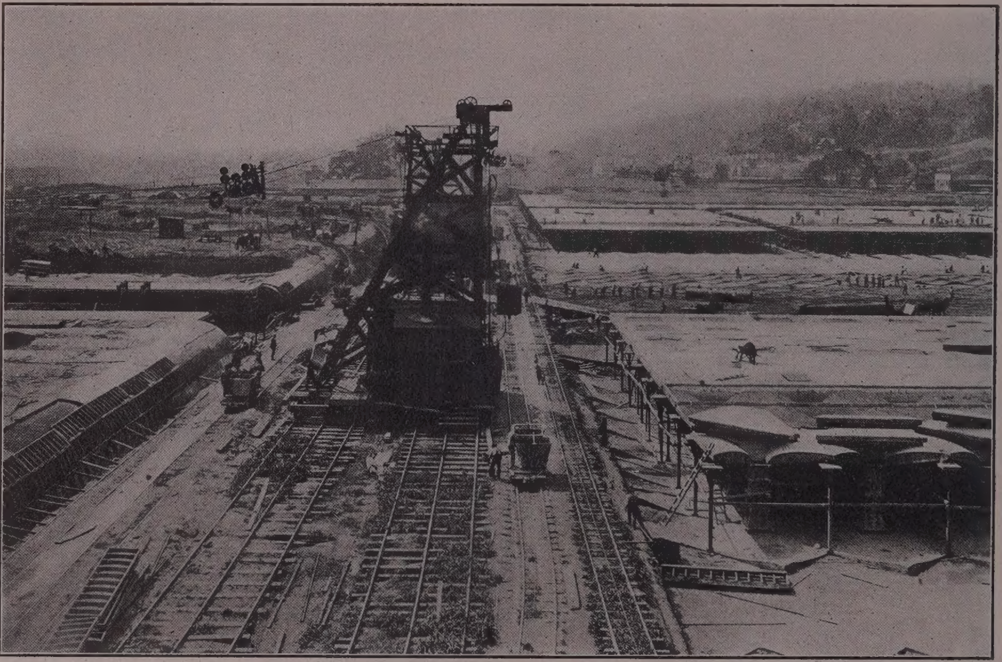
In the early part of the work a tramway system similar to the one which is now in service between the dock at the river and the central mixer plant furnishing concrete for the filters was extended to various parts of the site of the work. Independent concrete mixers were operated in connection with this tramway system and delivered the concrete in buckets to the point where work was in progress. This system was not found to be adapted, however, to the requirements of this particular work, so the central mixer plant and the cableways were substituted for it.

The back-filling of soil over the filters is made with 2-yd., four-wheel, bottom-dump wagons. After each filter is completed it is tested for leakage and after the construction work has been accepted the gravel and sand are placed in it.

Sand and Gravel Washing Plants.—The filter sand is washed at the main dock at the river and then transported on the tramway to sand storage bins under the tramway, which bins lie toward the river from the storage piles of concrete material. It is hauled from these bins in ¾-yd., two-wheel horse carts having 6-in. tires, to ventilator manholes in the roof of the filter being filled.

The system for handling and washing filter sand at the dock is particularly complete. The two derricks equipped with the clam-shell buckets deliver the sand to an overhead receiving bin erected on the platform of the dock. The bottom of this bin is a hopper having an inclined chute outlet. Jets of water are played into the corners of this bin from ¼-in. holes in supply pipes in order to keep the sand moving out of the bottom of the hopper. The chute delivers to a revolving cylindrical screen which separates from the sand all particles exceeding the limiting size. Jets of water from three 1-in. pipes placed just below a gate at the bottom of the hopper move the sand out of the inclined chute into the revolving screen and keep it in motion in the latter. The fine gravel rejected by the screen is discharged on the dock and is utilized in the preparation of filter gravel. The sand which passes the screen falls into a sand-washer tank 6 x 8 ft. in plan and 10 ft. deep. The bottom of this tank is a perforated sheet of metal through which water is supplied to the tank by an 8-in. centrifugal pump, the total area of the perforation in the bottom plate being equal to the cross-section of the discharge of the pump.

A weir at the top forms the overflow for this tank, the water passing up through the sand and removing the mud and finest sand. The consistency of the mixture of sand and water in the tank is such that sand can be drawn off readily with the water. Four small sluice gates are placed in the side of the tank, one above the other, and all discharging into the same hopper. The largest sand particles are drawn off through the lower gate, the next smaller size through the second gate and so forth. By adjusting the amount of opening the operator can keep the surface of the sand in the tank high enough to allow the finer particles to be washed over the weir with the waste water, thereby preventing any excess of fine material in the residual sand. The upper sluice gate in the side of the tank is considerably below the crest of the overflow weir and a plate-glass window in the side of the tank enables the operator to see the level of the sand.


Head Tower of Cableway Spanning Half of Filter Site.

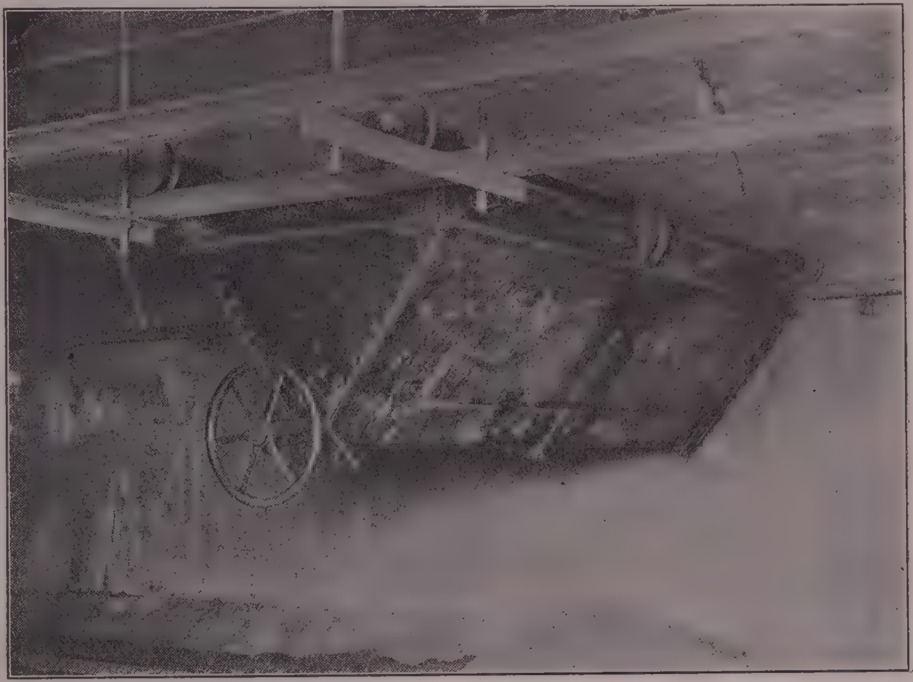
The hopper into which the sand and water from the four gates in the side of the washer tank are discharged is at the base of a set of flight conveyors which drag the sand up out of the water and elevate it to overhead storage bins, the water wasting over a weir without carrying any valuable material with it. The length of the flight conveyor and the slow speed of its movement enables the sand to be well drained before reaching the head of the conveyor runway. The sand is discharged from these bins through spouts into buckets on the tramway and is carried in these buckets on the tramway to the storage bins toward the end of the latter.

The gravel for the filters is delivered into overhead bins at the dock by the derricks, and from these bins into buckets on the tramway, the latter conveying it to a gravel washing and sizing screen under the tramway near the storage piles of concrete materials next to the central mixer plant. This screen consists of a 42-in. cylinder, 40 ft. long, made of steel plates with three cylindrical screens, 3 ft. long, placed at proper intervals in it. The cylinder is placed nearly horizontal, the slope from end to end being 5 in., and under it in a row are four storage bins, one for each grade of gravel. A 4-in. water pipe extends the length of the cylinder approximately at its axis. The gravel is dumped from the tramway buckets into a hopper at the high end of the cylinder and is fed into the latter by gravity, assisted by a jet of water from a 1-in. pipe, deflector blades in the cylinder moving it forward. The cylinder turns on rollers and is revolved by a spur gear, its length and weight precluding any method of shaft driving.

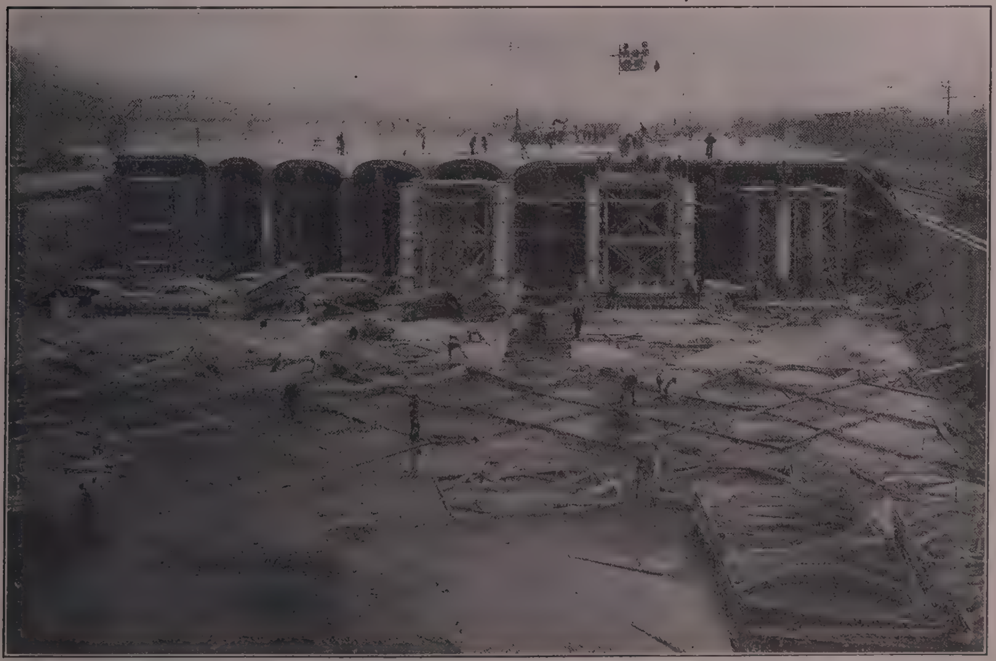
The smallest size of gravel is removed by the first screen, which has ⅝-in. meshes. Jets of water from ¼-in. holes in the interior 4-in. pipe, are played on this screen to assist in the washing. Two other cylindrical screens are placed concentrically around the ⅝-in. mesh screen in the main cylinder. The first of these concentric screens has ¼-in. meshes and is extended over the partition between the first and second bins in the row of four, so that the material retained by it is passed into the second bin. The second concentric screen has 1-mm. meshes and is so arranged that such material as is retained by it falls into the first bin while the particles that pass through it are carried away in the wash water. The second screen in the cylinder also has ⅝-in. meshes and assists in separating particles which have not passed the first screen. Jets from the interior 4-in. pipe are also played on this screen, which discharges into the second bin of the row. The third screen has 1¾-in. meshes and discharges the gravel passing it into the third bin. All gravel retained by the last screen is discharged from the end of the cylinder into the fourth bin.

The system of tracks in the filters on which the sandscraping and restoring machines will be operated are very useful in placing the filter sand and gravel. Two-yard steel hoppers, each mounted on a bridge carried by four wheels on the two rails of the tracks, have been provided for distributing the gravel and sand over the filter. The two-wheel carts dump the sand and gravel through the ventilators in the filter roof into these cars and the latter are then pushed to various parts of the filter on the tracks. A door 6 in. wide extends the full length of the bottom of the car and opens downward. This door is kept closed by ratchet wheels and when the car reaches the point where the material is to be dumped it is opened and the contents of the car discharged the width of the filter bay.

Filtered Water Reservoir.—The excavation for the filtered-water reservoir was made by a 70-ton Marion steam shovel operating part of the time in connection with 2-yd., four-wheel dump wagons and the remainder with dump cars on narrow-gauge tracks. The excavation required the removal of over 116,000 cu. yd. of material, two-thirds of which was in silt, and the remainder in river gravel. Most of this material was used in the embankment along the river side of the reservoir. A larger amount of the best part of the soil was stored at one end of the site and will be used in backfilling around the reservoir and over the roof of the latter. Some of the clay from the excavation for the sedimentation basins was also placed in this storage pile and will be used for the puddle that is to be placed over the roof of the reservoir.



Car used by Contractor in Distributing Sand and Gravel.



Narrow End of Filtered Water Reservoir under Construction.

The concrete work was carried on in two sections, one on each side of the approximate transverse center line of the reservoir. A cableway with traveling towers was set up longitudinally over the section to the west and handled the concrete for that portion of the work. This cableway had a span of 300 ft. and a carrying capacity of 4.5 tons. The same cableway was afterward set up transversely over the other section and also handled the concrete for that section. The section to the west was built first, the cableway being set parallel with the long axis of the reservoir because no embankment had been made on the river side of the site, and also to avoid the convergence between the two sides of the reservoir. When the construction reached the second section of the work enough of the embankment on the river side of the site had been built to carry the tracks for the head tower of the cableway, the tail tower being placed on tracks between the railroad and the skew side of the reservoir that were parallel to that side. The carrying cable and the endless haulage cable on the cableway were arranged so they could be lengthened or shortened as the towers were brought closer together or farther apart by the converging tracks. The towers would be moved 20 or 30 ft. parallel with the long axis of the reservoir, however, without changing the length of these cables.

The concrete for the reservoir was made in a Hains gravity mixer having a capacity of 400 cu. yd. a day that was erected on the bank of the river near the upstream corner of the reservoir. Gravel and sand were delivered to this mixer from scows in the river by a stiff-leg derrick equipped with a 1¼-yd. Hayward clam-shell bucket that was set up beside it. This bucket discharged into a bin for gravel and one for sand erected over the mixer. The cement was raised from the ground to a charging platform of the mixer by a bag elevator. The concrete was delivered from the mixer to the cableways in 1¼-yd. buckets on flat-cars which were hauled by light locomotives over narrow-gauge tracks laid to the site of the work.

The floor of the reservoir was laid in two 5-in. layers which were both placed in alternate squares in a manner similar to that followed in the construction of the filter floors. After a part of the floor over the first section had been completed the piers carrying the roof arches over that part were erected. A comparatively large portion of the first section was covered in this manner before the first winter season, and during the latter the forms for the roof arches for that portion were erected so that the concrete work on the latter could be rapidly carried forward when the season opened.

River Crossing.—The most hazardous work on the whole undertaking was the construction of the river crossing connecting the filtered water reservoir by two 72-in. steel pipes with the equalizing chamber at the Brilliant pumping station. This work was all carried on in cofferdams and as nearly as possible in the dry. Three cofferdams were built, the first extending out from the north bank of the river and covering a length of 300 ft. of the site; the second covering 350 ft. of the site at the middle of the stream; and the third extending to the south bank of the river from the end of the middle one, with a total length of 450 ft. The unusually porous nature of the bed of the river made the work in these cofferdams very difficult to execute. The sides of the cofferdam were placed from 165 to 175 ft. apart to increase the friction head against the water passing under them through the gravel. The two 72-in. pipes and the concrete surrounding them were laid in a trench about 60 ft. wide that was largely made with floating dredges in advance of the cofferdams. The sides of the cofferdams were thus at least 65 ft. from the center line of this trench, but even with this amount of river bed exposed the water came through the gravel in such quantity that from four to seven 12-in. centrifugal pumps were constantly employed in keeping the water level lowered in the cofferdam so work could be carried on in it. The frequent and sudden rises to which the Allegheny River is subject flooded the cofferdams, on the average, about once a month. With all of these difficulties the contractor completed the work on the under-water section of river crossing in 11 working months, the last cofferdam being built, the excavation in it completed, and the pipes laid and concreted in in a little more than two months.

The sides of the cofferdam which was against the north bank of the river and of the one against the south bank were made of a double row of 3x10-in. sheet piling, the rows being 12 to 14 ft. apart, and filled to the top with material from the bed of the river. The middle cofferdam had sides made of a single row of 6x10-in. sheet piling with an embankment on each side. All of this piling was driven and the embankments made with floating equipment.

The design of the river crossing calls for a row of 6x10-in. sheet piles on the upstream side of the concrete around the pipes which were driven as required. A row of 1½-in. tongue and grooved sheeting was also driven on the downstream side of the trench for the concrete to make a form in which the latter could be placed. These rows of sheet piling and the piles in the apron on the downstream side of the concrete were driven by drivers on rollers running on the finished work. The large piles of the apron were sunk into the gravel with considerable difficulty and the sheet piles were even harder to drive. The pipes were laid on temporary blocking in the bottom of the trench and the concrete was placed around in alternate sections about 30 ft. long. The concrete for this work was made in a portable Foote mixer. In the early part of the work this mixer was set up at one point and the concrete delivered from it to the site of the concrete laying on small cars on tracks laid over the pipes. Later the mixer was moved forward as the work progressed and delivered the concrete directly into place. The stone rip-rap was placed as soon as the concreting had been completed.

The work on the 50-in. pipe line extending from the distributing reservoir near the Brilliant pumping station to the Monongahela River involved a large number of difficult pieces of trench work as the line passes close to and under numerous structures of considerable size. The line also follows for some distance along several streets in the residence portion of the city carrying street railway lines, and in other places crosses some comparatively rough ground so that trenching under various conditions was required before the work was completed.

The 30-in. pipe under the Monongahela River was laid in sections 120 ft. long from pile bents driven in the bed of the river, and the joints between the sections made by a diver. The water at the crossing has an average depth of 24 ft. at normal stages and the work done by the diver was carried on with considerable trouble.

The standard concrete mixture that is required by the specifications where gravel is employed is one part cement, three parts sand and five parts gravel. Where reinforcement is used in the concrete a 1:2:4 mixture is used and in foundations, revetment, and other massive concrete a 1:3½:7 mixture is used. Atlas Portland cement has been employed almost exclusively, more than 240,000 bbls. having been consumed to date. Both square and Ransom twisted steel bars are used for reinforcement.

The data and information from which the foregoing articles have been prepared were supplied by the Bureau of Filtration of Pittsburg, Mr. Morris Knowles, chief engineer, and by representatives of the T. A. Gillespie Co. Mr. T. H. Wiggin was principal division engineer of the Bureau during the design and preparation of the final plans and the early construction work. Mr. F. E. Field, formerly in charge of the filters, sedimentation basins and appurtenances, succeeded Mr. Wiggin. Mr. Howard W. Underwood is in charge of the filters, sedimentation basins and appurtenances; Mr. T. C. Atwood is in charge of the filtered-water reservoir, the Allegheny River crossing and additions to the Brilliant pumping station; Mr. F. H. Robbins is in charge of the intake and the new pumping station, and its equipment; Mr. N. S. Sprague is in charge of the pipe line to the south side of the city; Mr. W. R. Copeland is in charge of the sanitation of the construction work and of the inspection of materials. Mr. John M. Rice is in charge of supplementary design as work progresses.

Mr. T. A. Gillespie, president of the company, has given much personal attention to the undertaking and has been on the work a good deal of the time. Credit for a great deal of the successful progress of the construction is due to him and to Mr. H. L. Gillespie, assistant to the president and vice-president.

Details of Vaulting Forms and Supports for Filters.

The ten contracts covering the entire filtration system were awarded to the T. A. Gillespie Co. Mr. Robert Swan is vice-president and general manager of that company and has general charge of the construction work. Mr. J. A. Nelson is engineer for the contractor for the work on the north side of the Allegheny River. Mr. Frank Wilcox is engineer for the contractor on the south side of the Allegheny River. Mr. M. J. Coffey is assistant general manager in charge of construction work. The assistant engineers for the contractor are as follows: Mr. Wm. H. Edwards, civil engineer; Messrs. C. L. Woolridge and H. M. Leh, mechanical engineers; Mr. H. L. McMillan is in charge of the preparation of filter materials.

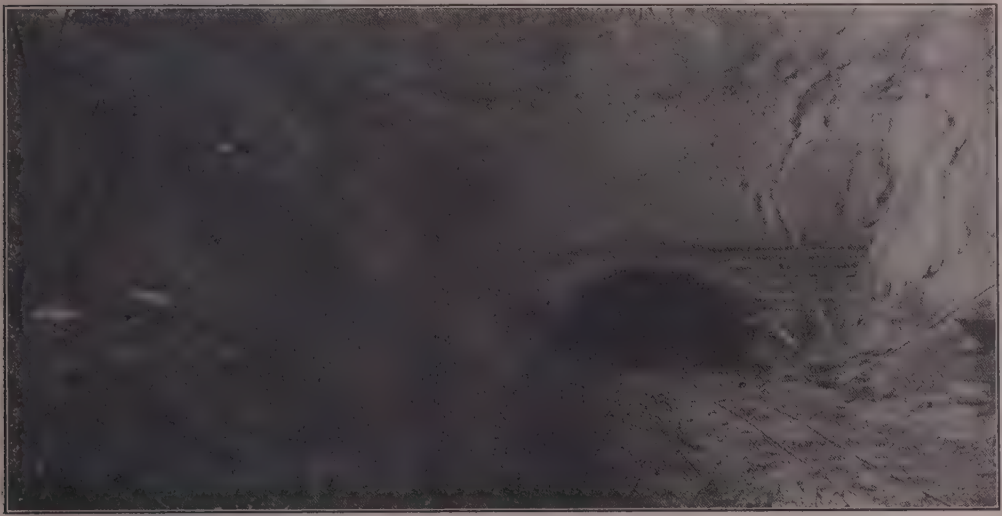
In addition to the various machinery and equipment sub-contractors that have been mentioned, the following materials were supplied as indicated: The sluice gates and electrically-operated valves, the Coffin Valve Co.; all other valves, the Ludlow Valve Co.; the riveted-steel pipe, the Thos. McNeil & Bros. Co.; cast-iron pipe and specials, R. D. Wood & Co.; piping around the pumping station, the Best Mfg. Co.; and the screw-joint piping, Spang & Chalfant.

Tests of the Strength of Soldered Joints.

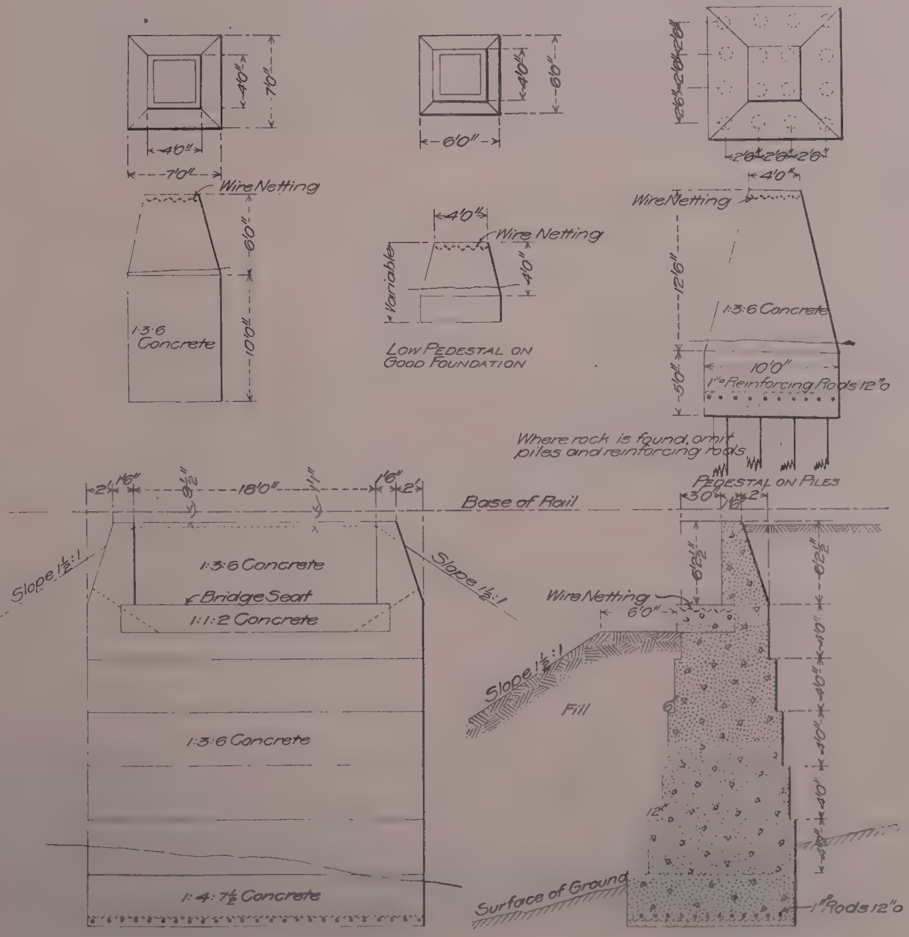
The strength of soldered joints has been found in thesis tests recently made at the Iowa State College to be a very uncertain quantity, varying widely with the composition of the solder, with the method of making the joint and with the kind of metals joined. It was found that the process known as "sweating" results in a joint of the least strength of any of the methods of soldering; all joints made with pressure were invariably found to be more or less granular or spongy, while those made without pressure are usually smooth and firm. In comparing different compositions of solder, it was found that a solder of 60 per cent. of tin to 40 per cent. of lead was the most suitable for general work in which considerable mechanical strength is required, although the actual strength of the joint was found to depend upon the kinds of metals joined. In a series of joints made on brass and on copper with solders containing from 35 to 70 per cent. of tin, practically all of them broke at loads under 13,000 lb. per sq. in. The maximum strengths on copper were obtained with 60 per cent. solders, the strength declining rapidly with higher percentages; this peculiarity on copper was believed to be due to the difficulty of maintaining the proper temperature in soldering, as with a slight excess of heat, the extreme fluidity of the high percentage compositions of solder cause it to run out of the joint. With brass, on the other hand, the strength increases as the proportion of tin in the solder is increased. In futher tests to determine the life of soldered joints under light loads, it was found that joints on brass have longer life under a given load than those on copper. An interesting feature of the observations made in the tests is that the time taken to break a soldered joint is an important factor in the results secured. All joints will after a short time fail under a stress much less than that required to produce failure at once; it was found in many instances that a decrease of five seconds in the total time of testing would increase the strength of the joint from 4,000 to 5,000 lb. per square inch, the total time of testing being usually 20 to 25 seconds. The maximum strength obtained was 25,900 lb. per square inch, in the case of a joint on copper with a 60 per cent. solder, the total time of testing having been shortened to 20 seconds.

The Tidewater and Deepwater Railways.—Part III.

From Moneta Eastward.—Generally speaking, the line follows the valley of Goose Creek, or valleys of its tributaries from the heavy cut near Moneta to the point where it joins the river valley again. It cuts across the country at various places, however, in order to avoid sharp bends in the streams or to secure a place to hold to the grades. Two cuts, one of 50,000 and one of 60,000 cu. yd., are encountered in the two miles east of the 260,000-yd. cut, and in the following six miles the line crosses over the tops of the hills at considerable elevation above the streams in the vicinity. In this six miles the grading runs from 50,000 to 120,000 cu. yd to the mile and consists in cutting through the tops of the hills and in filling or bridging the valleys between them. One cut of 100.000 and one of 90,000 cu. yd. are required, several fills from 75 to 100 ft. high are being made, and a viaduct 100 ft. high and 480 ft. long is to be built in this six miles. The fills are largely over the valleys of streams which carry considerable quantities of water, and the latter is carried through the fills in concrete culverts or plate-girder bridges.


Portal of Heading of Last Tunnel to the East on Tidewater Ry.

At the end of this heavy work is a 400-ft. tunnel that was driven through seamy rock which was stratified in various directions and caused considerable difficulty. In driving the heading drifts were run in on each side, 12 to 50 ft., then the wall-plate timbers were placed, after which the core was removed. The heading has been timbered throughout, the lining consisting of 4-in. lagging with 12x12-in. timbers, placed 2 ft. apart on centers. A Sullivan straight-line air compressor, with a capacity of 900 cu. ft. per second, is set up near one portal of the tunnel and supplies air through a pipe line extending to the other portal from which the heading has been driven.


Typical Concrete Abutments and Pedestals for Steel Viaducts.

The material from this tunnel is being taken out to the east and used to build a high fill along the side of the valley of Goose Creek, a tributary of the Staunton River. From the tunnel the line is slowly dropping to the east down Goose Creek Valley, and for five miles the grading work is light. At the end of this five miles of light work the creek makes a sharp turn to the left around a high crag of rock, but by making a stream crossing on each side of this hill and by cutting through the latter this bend is avoided and considerable distance saved and curvature eliminated.

In the mile beyond these two stream crossings and the cut through the hill, two cuts in loose rock amounting to 117,000 cu. yd., have been made with a 60-ton Vulcan steam shovel working in connection with trains of 3-yd. cars.

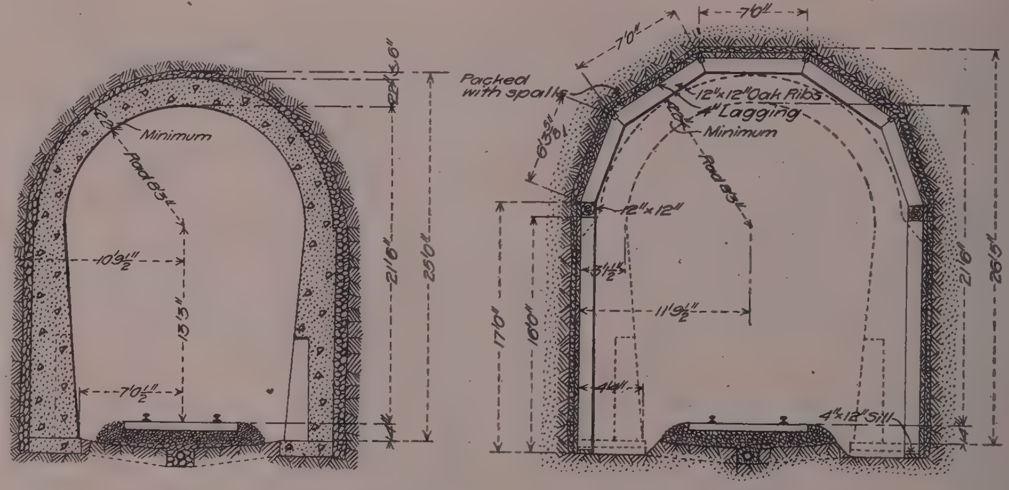
The creek makes another long bend in the next mile which is avoided by driving an 840-ft. tunnel through a pinnacle of rock that rises abruptly to a height of 200 ft. directly from the bed of the creek at the west portal of the tunnel. A 28,000-yd. cut in rock is being made at the approach to the east portal. From the latter to the mouth of Goose Creek in the river, a distance of about two miles the line cuts along the side of short, rugged rock hills and the grading is heavy. At less than a mile from this tunnel, a second tunnel had been planned, but seamy rock necessitated an open cut which contains about 24,000 cu. yd. in 450 ft. A straight-line Sullivan air compressor with a capacity of 900 cu. ft. a minute is installed near the latter cut, and supplies air through a pipe line about half a mile long to drills in the tunnel heading and in the rock cuts in the vicinity.

A crossing of the river is made at the mouth of Goose Creek on a deck plate-girder bridge. This bridge has a total length of 382 ft., and is carried on concrete piers having a total height above their footings of from 24 to 39 ft. The name of the river between the point where the line left it just east of Roanoke and the mouth of Goose Creek is changed from the Roanoke to the Staunton River and bears the latter name for some distance. Beyond the crossing just mentioned, the line is along the right side of the river valley with easy grading for five miles to a second crossing made on a deck plate-girder bridge, the spans of which are also carried by concrete piers. The river bank at the east approach to this bridge is a rock cliff which rises abruptly from the edge of the water. A 700-ft. span cableway made by the American Hoist & Derrick Co. was set up longitudinally over the bridge site and used in the construction of the piers. The rock was quarried from the cliff forming the river bank and carried across the river in skips by the cableway to a crusher on the opposite side of the stream. The concrete was mixed on that side of the stream and handled to position by the cableway.

A 75,000-yd. fill has to be made as the west approach to this crossing and a 58,000-yd. fill just to the east of the east approach. Other than these two fills, the grading continues fairly light for nearly 4 miles to a point within a mile of a tunnel that is driven to cut off a bend in the river. The approach to this tunnel requires two high fills, and the necessity of constructing a station ground and passing track coming in this approach materially increases the yardage in them.

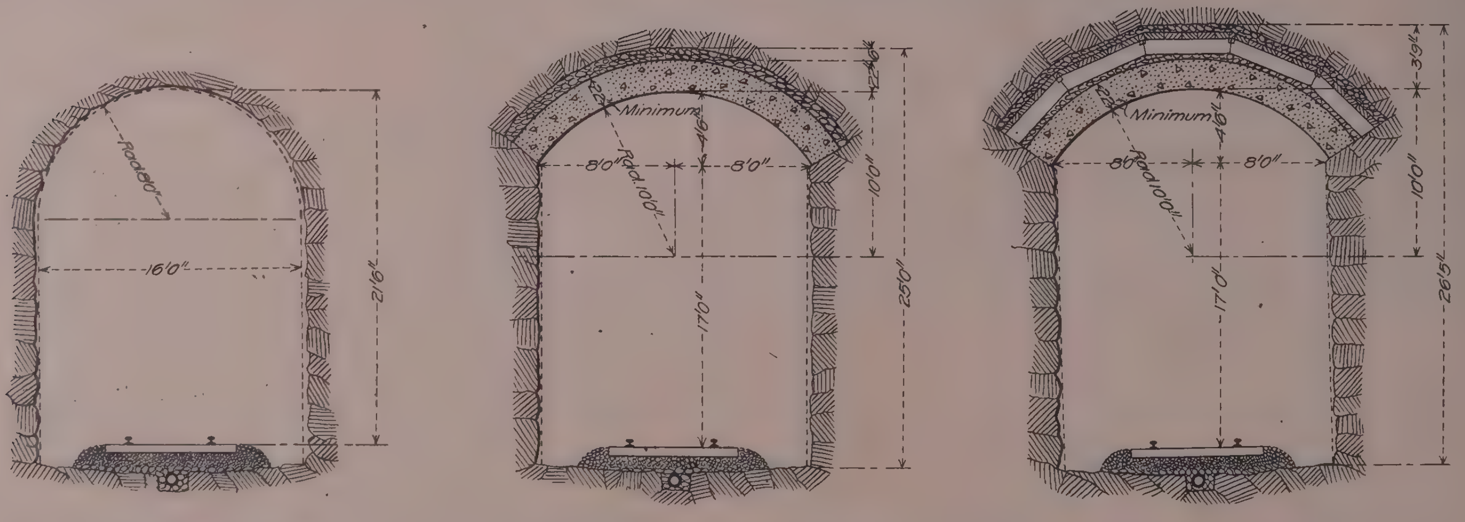
The tunnel is the last one on the line and has a total length of 789 ft. The heading was all driven from the west end and in the first 300 ft. passed through disintegrated rock which contains considerable mica and which goes to pieces on being exposed to the air. This material caused considerable difficulty in the heading and at the portal, the timbering being required to follow closely after the excavation. Drifts were run in on each side for 15 to 20 ft. for the wall plate timbers, which were placed as fast as possible and then the core removed. During the progress of the tunnel work a slide occurred at the portal and filled the entrance to the latter. The slopes of the approach cut had to be carried back for a considerable distance and the portal heavily timbered to prevent further slides. The heading was driven to the rate of about 140 ft. a month with a single shift, and was lined with 4-in. lagging, held in place by 12x12-in. timbers placed from 2 to 4 ft. apart on centers, depending on the material.

Standard Tunnel Linings.—This being the last of the tunnels on the line the standard sections and the methods of lining that have been adopted for single-track tunnels in various kinds of material are illustrated herewith. Type A is the standard section for tunnels in solid rock where no danger of falls are liable to occur. This section requires 12.63 cu. yd. of excavation per linear foot of tunnel. Type B is the standard section for tunnels in solid rock where the tunnel has firm sides, but where there is danger of falls in the future. The lining of the arch is 1:2:4 concrete. This section requires 14.8 cu. yd. of excavation and 1.435 cu. yd. of arch masonry per linear foot of tunnel. Type C is a section adopted for tunnels having firm sides and yielding roof. The lining in this case is 1:2:4 concrete. This section requires, per linear foot, 16.23 cu. yd. of excavation; 1.435 cu. yd. of arch masonry, and 171 ft. board measure of timbering, based on ribs being spaced 5 ft. apart on centers. Type D is the section adopted for firm but not self-sustaining material. The lining is made of 1:3:6 concrete. This section requires, per linear foot, 18.537 cu. yd. of excavation, 1.955 cu. yd. of arch masonry and 3.085 cu. yd. of side wall masonry. Type E is the section used for tunnels in yielding material. The concrete in this case is a 1:2:4 mixture. The 4x12-in. sill shown is used in hard material only; in soft material a 12x12-in. sill is used. This section requires, per linear foot, 21.82 cu. yd. of excavation; 1.955 cu. yd. of arch masonry; 4.323 cu. yd. of side wall masonry and, based on a rib spacing of 4 ft. center to center, 489 ft. board measure, of timbering. The thickness of concrete shown is the least that is used and is increased as required. All sections are widened on curves as required. Vitrified pipes are laid with open joints in the drain as shown, their size depending on the length of the drain and the amount of water to be removed. Weep holes are provided in lined sections where necessary and are connected with the longitudinal drain by cross drains.



Type D. Firm But Not Self-sustaining Material. Type E. Yielding Material

Standard Tunnel Sections.



Type A. Firm Solid Rock, No Danger of Falls. Type B. Solid Rock, Firm Sides and Roof, Danger Future Falls. Type C. Solid Rock, Yielding Roof, Firm Sides.

Standard Tunnel Sections.

From this last tunnel that was driven to avoid a bend in the Staunton River to the point where the line leaves the latter 3 miles east of Brookneal, in a distance of 27 miles, the track is from a few feet to one-half mile from that river, and follows along on a water grade. In most of this distance the grading consists of side hill cuts practically all of which are in loose or disintegrated solid rock. At some points where the river is close to the hillsides on which the track is carried, numerous short hills project out to the edge of the water and occasional heavy cuts have to be made through them. This work is completely isolated from a railroad so that steam shovels or other plant could be brought in only with considerable difficulty, and as the hauls from the cuts to fills are generally short, much expense for placing plant has not been justified. For these reasons carts and cars have been used.

The 32 miles of work that is now being done by the Lane Bros. Co. ends 2 miles east of the tunnel just mentioned. The contract for the next 20 miles of construction was awarded to Messrs. Carpenter, Frazier, Boxley & Co., and for the following 6.5 miles, extending 5 miles east of Brookneal, to Butler Bros. Construction Co.

From the point where the line leaves the valley of the Staunton River, it cuts directly across the watersheds of numerous streams tributary to that river for about 25 miles until it reaches a ridge running generally east and west which forms the dividing line between the watersheds of streams flowing to the north and those flowing to the south. In cutting across the country in this manner, the most difficult work on the entire line has been encountered in order to secure grades that would not exceed the maximums that have been established. Various surveys were made in an attempt to secure a less expensive line, but a ridge north and south from Meherrin precluded the possibility of as good a line to the south. That is, the line could not be taken down into the valleys on each side of this ridge and cross the latter, nor could the Nottaway or Meherrin Rivers be followed satisfactorily.

Within two miles of the point where the Staunton River valley is left a crossing of Falling River is made. This crossing consists of a steel viaduct 1,650 ft. long and with a maximum height of 90 ft. and an average height of 80 ft. It has regular 30-ft. towers and 60-ft. spans with a 90-ft. span over the stream.

The grading west from the Falling River crossing for three miles is heavy, the line cutting across on the tops of the hills which run out into the valley of the Staunton River. East of the crossing of Falling River the work is of similar character. Two miles from the crossing a 190,000-yd. cut is being made with a Bucyrus steam shovel in material that varies from earth to solid rock in strata of varying hardness making blasting difficult. The material from this cut is practically all being hauled out in trains of 4-yd. standard-gauge dump cars to make a 135,000-yd. fill located at a point about half a mile west of the cut.

In the next eight miles beyond this 190,000-yd. cut the line breaks across the tops of the rolling hills which form the country and the grading averages upwards of 100,000 yd. to the mile, being nearly all through clay of various kinds with occasional outcroppings of loose rock. About 5 miles from the big cut is an 85,000-yd. fill over Little Louse Creek, the stream being carried in a 15x15-ft. arch culvert. A short distance beyond this is a 175,000-yd. fill over Louse Creek which has a maximum height of 80 ft. and is made in 1,300 ft.

Four Bucyrus steam shovels are installed on this portion of the work. They were brought in over a standard-gauge tramway which the contractors extended from a branch of the Norfolk & Western R. R. near the crossing of Falling River. This tramway is 7 miles long and over it have been handled all of the supplies that have been used on this heavy work.

Although the line still remains on the tops of the hills until the ridge is reached, in the next 7 miles several streams of considerable size are crossed, and their wider and deeper valleys are spanned by steel viaducts. The first of these viaducts in order is the one over Cub Creek; it is 650 ft. long and has a maximum height of 90 ft. The next one is over the West Branch of Ward's Fork; it has a total length of 720 ft. and an average height of about 80 ft. The third one of these structures is over the valley of the East Branch of Ward's Fork; it has an average height of about 60 ft. and is 1,380 ft. long. The fourth and last of these viaducts spans the valley of Terry's Creek, and is 1,140 ft. in length, has a maximum height of 80 ft. and an average height of 70 ft.

Views of Standard 12-Ft. and 5-Ft. Arch Culverts.

These structures all have 30-ft. towers and 60-ft. spans, the same as in those farther to the west that have already been mentioned. Their tower legs are carried on concrete pedestals and they have concrete abutments. The details of the type of pedestals that have been adopted for the numerous high viaducts along the line are shown in one of the accompanying illustrations made from the plans of the masonry work for the Cub Creek viaduct. The general type of concrete abutments that have been adopted for the various bridge structures is also shown in one of the illustrations that was likewise reproduced from the masonry plans for the Cub Creek viaduct.

The country in the remaining 7 miles beyond the last of these high viaducts to the point where the line joins the ridge continues to be rough and broken, but the grading work is somewhat lighter. The grading in this 7 miles has largely been completed with five Bucyrus steam shovels operating in connection with trains of narrow-gauge cars and locomotives. Part of this same plant was also used in making an 87,000-yd. cut near Abeline, and about 7 miles from Meherrin, where the line joins the ridge and a second cut containing about 100,000 yd. that was made through a short cross ridge at a point about a mile beyond Abeline where the main ridge is disconnected.

The McDermott Contracting Co. has the contract for the 26½ miles of grading extending from a point near this last heavy cut mentioned across the rough country to the west, including about 1,500,000 cu. yd. of pay quantities. This company has built a standard-gauge tramway, 6 miles long, extending from the Southern R. R. to within a short distance of the point where the line leaves the ridge. All of the plant, equipment and supplies used on the eastern end of its work have been brought in over this tramway.

The dividing ridge which the line follows is practically continuous from the point where the line joins it 5 miles west of Meherrin to within 70 miles of Norfolk. The line in the 75 miles from the end of the work being handled by the McDermott Contracting Co. to the point on the east where the ridge runs out, about 60 miles from Norfolk, is made up of a series of flat curves and long tangents which hold the track to the general contour of the country and obtain easy grades. The ridge gradually runs out to the east and the grades are descending in that direction, almost without exception, but rarely at the maximum established rate of 0.6 per cent., compensated, against westbound traffic.

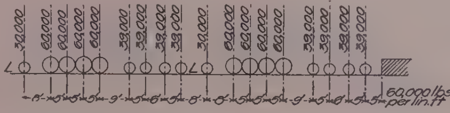


Diagram Showing Bridge Loading.

The grading work in this 60 miles is at no place particularly heavy, and is all largely through various kinds of clay and disintegrated rock. This work and all of that to the east of it has been carried on with considerable difficulty, however, owing to the two unusually wet seasons which have occurred since the contracts were awarded for the first 103 miles on the Tidewater Ry. from its eastern end. The summers of 1905 and 1906 have been unprecedented in Virginia for the amount of rain that has fallen and the continuity of wet weather. During July and August, last, for instance, there was recorded over 10 and 15 in. of rain, respectively, at one point on the line, and this is probably about an average over the eastern 150 to 160 miles of the work. The clay and other material through which many of the heavy cuts have been made during these two seasons are practically impossible to work in wet weather and have caused no small amount of trouble. The placing of plant and the hauling of supplies to the work has also been done at heavy expense, as in many places the construction is isolated from railroads, and the highways are unimproved, almost without exception. Where tramways have been built they are considered to have very much more than justified the cost of their construction in the reduced cost of placing plant and equipment, aside from the saving of time procured by them. The wet weather has also interfered with the grading work between Brookneal and Roanoke; but in this distance the difficulty in placing plant and hauling supplies has been the most serious as the construction work is all isolated from railroad connections.

The 22 miles of grading to the east from the 100,000-yd. cut last mentioned is being handled by Messrs. A. & C. Wright and W. R. Bonsal & Co. The first 10 miles of this work runs about 40,000 cu. yd. to the mile on an average and has been handled largely with steam shovels, three of which have been installed, including a 70-ton Marion, a 60-ton Vulcan and a 45-ton Vulcan. Two miles from the end of this contract at Victoria is to be located the yard where engines will be changed on the run from Roanoke to Norfolk. An engine house, a coaling station, division offices and a large storage and classification yard will be located at this point.

The ridge becomes more flat east of this division yard, but the grading continues to be of about the same character for nearly 40 miles to a grade crossing of the Atlantic Coast Line R. R. at Jarratt. The grading in the first 20 miles of this distance to an overhead crossing of the main line of the Seaboard Air Line R. R. is being done by J. G. White & Co., of New York. This company has constructed a standard-gauge tramway, 7 miles long, extending from the last railroad crossing mentioned along parallel to its work. Three steam shovels, a 70-ton Atlantic, a 70-ton Vulcan and a 20-ton Marion, have been brought in over this tramway and are in service making a number of long cuts that are included in this company's work, one of which contains nearly 100,000 yd. Standard-gauge 6-yd. dump cars are used in connection with these shovels and are handled by regular standard-gauge locomotives. The material from the cuts is practically all utilized in fills, which are being made from pole trestles with the standard-gauge plant.

The work in the next 8 miles beyond the crossing of the Seaboard Air Line R. R. is being carried on by Messrs. A. & C. Wright, who have installed an automatic Thew steam shovel and a 70-ton Vulcan steam shovel. In this 8 miles three cuts of considerable length and depth have been made which have quicksand in the bottom, with occasional outcroppings of rock. The material has been taken out of these cuts with a great amount of difficulty during the rainy seasons that have prevailed since the work was started.

The grading in the last 95 miles extending to the terminal of the Tidewater R. R. at Sewall's

Point, 10 miles beyond Norfolk, has been done in alternate sections of various length by the MacArthur Bros. Co., and by Messrs. Sands & Oliver, the former having 42 miles in all, and the latter, the remainder, except two miles of grading near Norfolk that was done with a hydraulic dredge.

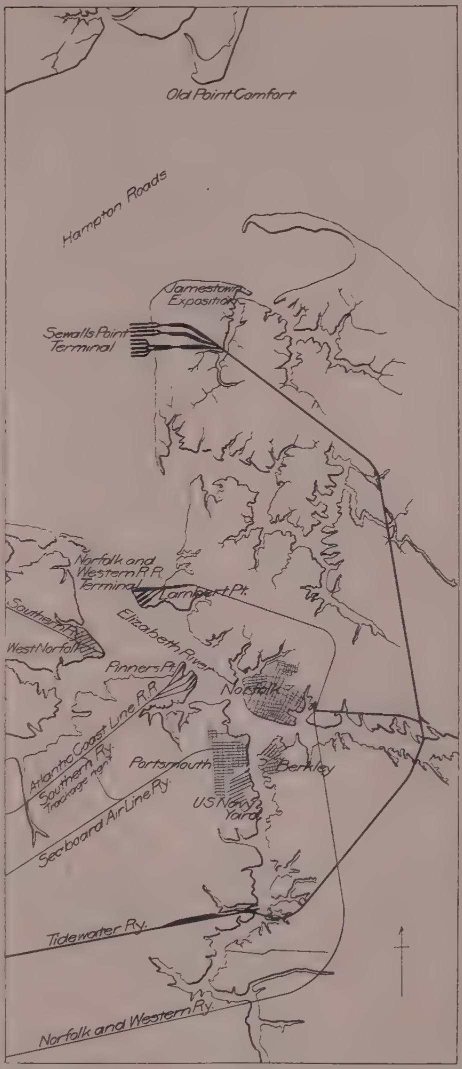
The heavier portions of the grading in first 65 miles of this work extending nearly to Suffolk, at 30 miles from the end of the line, has been done with steam shovels served by narrow-gauge cars and locomotives. The balance of the work has been done with carts and cars hauled by horses and mules. Here again the wet season interfered with construction and progress was made with difficulty.

Suffolk is near the northern edge of the great Dismal Swamp and five of the six railroads entering Norfolk from the south pass within about a mile of the same point near the northwest corner of that swamp. In order to avoid crossing any of these railroads at grade the track of the Tidewater Ry. has been placed in a cut through Suffolk, which permits it to make undergrade crossings of those railroads it does cross. This cut and those required on the grades approaching it were made with much difficulty as the ground is low and is underlaid with a stratum of quicksand under which, however, is a firm stratum of marl that is practically continuous under the entire surrounding country. A top cut was first taken out with wheel scrapers or a steam shovel. Then a trench wide enough to carry a track was cast out, timbers were laid in the worst places and a track put down, after which the cut would be finished by hauling the material out in cars on the track. The latter was maintained with much difficulty until the cuts could be carried down below it and drained. No further trouble is expected from the quicksand, however, after the track has all come to a bearing on the marl.

Between the eastern end of the approach cuts to the undergrade crossings in Suffolk to a crossing of the southern branch of the Elizabeth River, a tidal stream near Norfolk, the country is all very low and swampy, and for 13 miles the line passes through the edge of the Dismal Swamp on an embankment. In building this embankment men in rubber boots were first sent ahead and threw up just enough of a bank from side trenches with forks and shovels to hold the cross ties of a track. The rails of the latter were then laid and material brought in on flat cars from the cuts near Suffolk and unloaded with a Lidgerwood unloader. This embankment through the swamp and the cuts in the vicinity of Suffolk were made by the MacArthur Bros. Co.

A large yard for handling export and import freight, excepting coal, is to be laid on the west side of the crossing of the southern branch of the Elizabeth River. A pier has been built at this point and a slip dredged out on each side of the latter to a depth of 20 ft. at mean low water. Material dredged from these slips and from the river in the immediate vicinity has been used in making the embankment on which the tracks are to be laid for 4,800 ft. from the southern branch crossing.

This embankment is from 10 to 25 ft. high and contains in the 4,800 ft. about 260,000 cu. yd. of material. It was all made by a hydraulic dredge, owned and operated by the Atlantic, Gulf & Pacific Co., which pumped the material the full length of the embankment. The latter was also carried up to its full height by the dredge with a single lift. The material is mostly all a sandy loam mixed with shells.



Map of Norfolk, Va., and Vicinity.

Typical Portions of Construction Work Along the Staunton River.

The location of the line in the vicinity of Norfolk may be seen from the accompanying map of that locality. Four miles beyond the crossing of the southern branch of the Elizabeth River the eastern branch of that stream is crossed and then the line skirts around to the rear of Norfolk and extends 10 miles beyond that city to a tidewater terminal on Hampton Roads at Sewall's Point. A connection will be made over the tracks of the Norfolk & Southern R. R. with a passenger station in Norfolk.

The crossings of the two branches of Elizabeth River are both made on double track bridges. The one over the southern branch has three 135-ft. fixed spans and one 284-ft., center-bearing draw span; the other has three 135-ft. and one 110-ft. fixed spans and one 180-ft., center-bearing draw span. These spans are carried on heavy concrete piers built on piles. The superstructures are heavy riveted Pratt trusses designed for Cooper's class E-60 loading. The draw span of the bridge over the southern branch was fully described in The Engineering Record of August 11, 1906, and from that description the general type of both superstructures may be drawn.

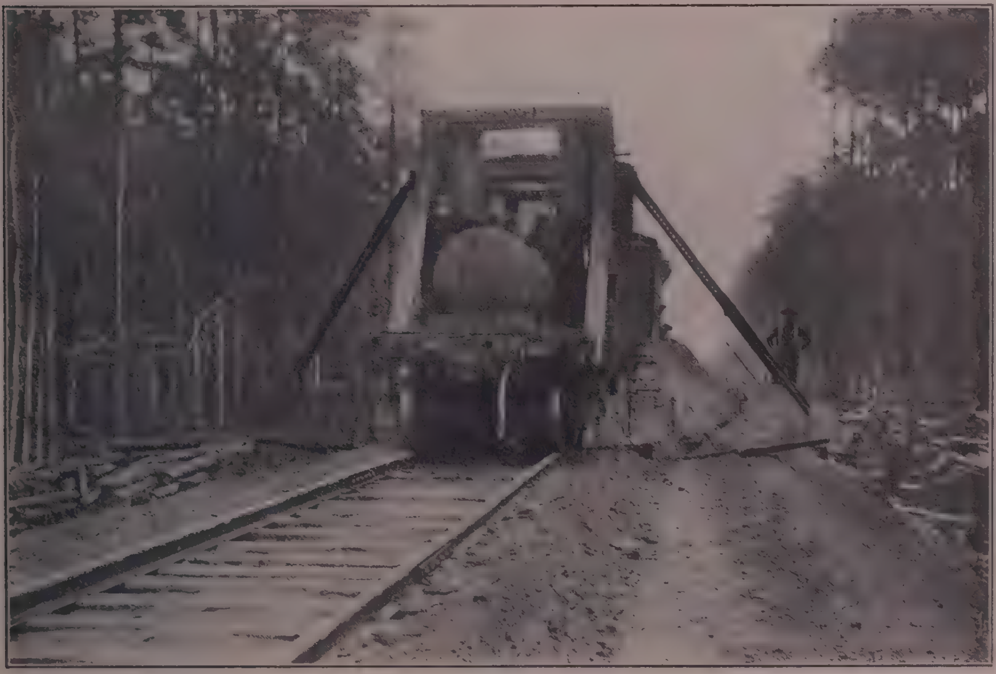
All steel bridges and viaducts on both the Tidewater and Deepwater Rys., are designed to carry the same live loading for which these two structures have been designed, namely: A live load on each track consisting of two Cooper class E-60 locomotives coupled and followed by a uniform train load of 6,000 lb. per linear foot as per the accompanying diagram. The proportioning for wind pressure, impact, centrifugal force and eccentricity is made according to usual first-class practice.

Terminal Facilities for Coal Traffic.—A large terminal storage yard is to be built and the coal-handling piers necessary to handle traffic are to be erected at Sewall's Point. As may be seen from the accompanying map this terminal is on Hampton Roads about 12 miles from open water in Chesapeake Bay. It is in such a position that with a small amount of dredging a channel having at least 30 ft. of water at low tide can be readily cut through to the wide and deep channel through Hampton Roads. The many advantages of this location are evident. The railroad company owns a large tract of land with a water front of about three-quarters of a mile at this point. The ultimate plans have been made to cover the most economical development of this water front, but for the present only one coal-handling pier will be erected.

This pier will be a steel structure, 1,300 ft. long, with 25-ft. towers and 50-ft. spans between the towers, the tower legs being carried by concrete and piles in steel caissons. The sub-structure will be protected by an independent wooden pile pier built as a fender and made strong enough to relieve the regular pier from any strains or shocks due to vessels striking it. Vessels will be loaded by gravity from both sides of the pier, and the latter is arranged so that several vessels may be loading simultaneously.

The general arrangement of the storage yard which the pier will serve and the general arrangement of the pier is briefly as follows: A large loaded car yard, into which the coal for various vessels has been assorted, will be built just back of the pier. Between this yard and the pier a car dumper similar to those installed for handling coal and ore at various points on the Great Lakes and at New York City by the Delaware, Lackawanna & Western R. R. will be erected. This dumper will lift each car, tilt it over and discharge its contents into a specially designed bottom-dump car of 60 tons capacity, 15 or 20 of which cars will be operated in connection with the pier. The empty railroad cars are shunted into an empty car yard from which they can be removed in trains.

A track will lead up an incline from the car dumper to the top of the pier, which is about 60 ft. above the water. This track will connect with a track along each side of the pier. The special bottom-dump cars that will be used in connection with the pier will be pushed up the incline by a heavy carriage mounted on a four-wheel truck and pulled up the incline by a cable on a hoisting engine. Each dump car will be equipped with a motor by which it will be propelled along the pier to the desired location after it has reached the top of the incline.



Ballast Spreading and Embankment Grading Machine.

All types of vessels with various spacing of hatches have to be loaded at a pier of this kind. The usual arrangement of gravity coal piers is to discharge the coal directly from the cars into which it was loaded at the mine into the hold of the vessel, necessitating a side or bottom-dumping car. A large portion of the cargo may be loaded in this manner without difficulty, but the last part of a cargo has to be placed in the corners of the hold and leveled or "trimmed" by hand, which process is slow and results in cars being held on the pier, while it is being done. To avoid such delay, pockets having a capacity of 60 tons each will be placed along both sides of the pier about 25 ft. apart. The main portion of the cargo will be loaded from bottom-dump pier cars in the usual manner. The remainder of the coal used during the trimming will be drawn as required from the 60-ton pockets along the side of the piers which can be filled quickly by the special bottom-dump cars.

By combining the coal dumper, special pier cars and the combined direct and storage method of loading vessels it is believed that the delay of cars will be practically avoided and several vessels may be coaled simultaneously with more ease. The car dumper will have a capacity of handling 30 cars an hour, or 1,500 tons, which is equal to 15,000 tons in 10 hr. or about 4,500,000 tons a year, counting 300 working days. If this capacity cannot be secured, a second dumper will be installed. Considering trains of eighty loaded 100,000-lb. cars to be hauled from Princeton to this terminal and allowing for passenger and local freight trains, eighteen such coal trains per day will be the maximum average number that could be handled. That number of trains would deliver about 60,000 tons or an amount equal to four times the capacity of the first pier that will be built, but provision has been made for the ultimate erection of additional piers of the same size and type and they will be constructed as traffic requires.

General Traffic Available.—Although the Tidewater and Deepwater Rys. have both been built with the primary object of handling coal traffic economically from the coal fields of West Virginia to eastern railroad connections and to tidewater, a large amount of other traffic will doubtless be originated and handled. In a large portion of the territory tributary to the Deepwater Ry. in the coal fields there are still large tracks of virgin timber of good quality. At various other points along both railroads large areas of land exist that could be readily utilized for the cultivation of timber. In addition to these resources, much of the country through which the Tidewater Ry. passes in Virginia is fertile, but has hitherto remained undeveloped owing largely to a lack of transportation facilities.

Laying and Ballasting Track.—The track on the eastern end of the Tidewater Ry. has been laid for a distance of about 90 miles from Sewall's Point, and construction trains are in operation over it. A Holman track-laying machine has been used in laying the track that is completed. Track laying will also be carried on in both directions from Brookneal, from Roanoke, and probably from Big Stony River, as soon as the grading work is ready.

A ballast spreading and embankment grading machine made by the O. J. Jordan Co., of Chicago, Ill., has been used successfully on the first 90 miles on the eastern end of the Tidewater Ry., in bringing the sides of the embankment to grade and in widening embankments after the track has been laid. A view of this machine on a section of embankment which it has just finished is shown in an accompanying illustration. The machine consists essentially of two steel shod plows each pivoted at one end on the side of a frame built up on a flat car. When not in use these plows are fastened back against the side of the car so that the clearance requirements of the latter are not increased. When in use the plows are extended at the sides, as shown in the accompanying view, at whatever angle desired. They are held in that position by horizontal braces which cannot be seen in the picture, that extend back to the car and are adjustable in length. A short fender closes the space between the outer edge of the rail and the inner edge of the plow when in position.

The two plows may be raised and lowered as desired and are controlled and operated entirely by air-cylinders mounted on the car. These cylinders are supplied with air under pressure from a storage chamber on the car that is filled by the compressors on the locomotive attached to the car.

The machine has thus far been used on this work for leveling embankments and for such work is brought along after the track has been laid and final filling placed. From the illustration it may be seen that the material is spread out over the ends of the ties and then a shoulder is cut by the plows, with a second shoulder farther out. The machine has also been found of much service in bringing narrow fills to the standard width after the track has been laid by its operation in connection with a Lidgerwood unloader.

The track of both railroads will be laid throughout with 85-lb. rails and ballasted with broken stone. The portion of the Deepwater Ry. on which track has been laid is being ballasted with broken stone from a quarry of good sandstone that has been opened about 40 miles from Deepwater. Two No. 6 Austin crushers have been installed at this quarry and will supply stone to ballast the first 80 miles of the Deepwater Ry. The next 24 miles will be ballasted with stone from a quarry at Princeton. Three quarries will be opened to supply stone to ballast the remainder of the track, one just east of New River, one just east of Roanoke, and one 45 miles beyond that near the last crossing of the Staunton River. The latter quarry will be called upon to supply stone to ballast the eastern 200 miles of the Tidewater Ry.

The construction of the Deepwater and Tidewater Rys. is being carried on under the direction of Mr. H. Fernstrom, as chief engineer. Mr. W. N. Page is president of the Tidewater Ry., and Dr. J. O. Green is president of the Deepwater Ry. Mr. Raymond Du Puy is general manager of both railroads. Mr. B. T. Elmore is assistant chief engineer; Messrs. L. R. Taylor and E. Gray, Jr., are principal assistant engineers; Mr. F. F. Harrington is engineer of bridges, and Mr. C. H. Stengel, designing engineer. Mr. C. P. Howard was chief engineer during the time preliminary surveys were being made.

A 22 Mile Cut-off is under construction on the Wheeling & Lake Erie R. R. between Orrville and Bolivar, Ohio, for the purpose of obtaining a lower grade. The maximum grade will be reduced from 53 to 21.1 ft. per mile and the distance will also be reduced by 6.6 miles. The maximum curvature will be reduced from nine to three degrees, and total length of curvature from 11.85 miles to 5.6 miles.

The Warming and Ventilation of Churches, Halls and Theatres.

By Charles L. Hubbard, Consulting Engineer, Boston.

Churches.—Churches may be warmed by furnaces, indirect steam, or by means of a fan.

For small buildings, the furnace is more commonly used. This apparatus is the simplest of all and is comparatively inexpensive. Heat may be generated quickly, and when the fires are no longer needed they may be allowed to go out without danger of damage to any part of the system from freezing. It is not usually necessary to make the heating apparatus large enough to warm the entire building at one time to 70° with frequent change of air. If the building is thoroughly warmed before occupancy, either by rotation or by a slow upward movement of outside air, the chapel or Sunday-school room may be shut off until near the close of service in the auditorium, when a portion of the warm air may be turned into it. When the service ends, the switch damper may be opened wide, and all of the air discharged into the Sunday-school room. The position of the warm-air registers will depend somewhat upon the construction of the building, but it is well to keep them near the outer walls and the colder parts of the room. Large inlet registers should be placed in the floor near the entrances to stop cold draughts from blowing up the aisles when the doors are opened, and also to be used as foot-warmers.

Ceiling ventilators are generally provided, but should be no larger than is necessary to remove the products of combustion from gas-lights, etc. If too large, much of the warmest and purest air will escape through them. The main vent flues should be placed in or near the floor and should be connected with a vent-shaft leading outboard. This flue should be provided with a small stove or flue-heater made especially for the purpose. In cold weather the natural draught will be found sufficient in most cases.

The same general rules follow in the case of indirect steam as have been described for furnace heating. The stacks are placed beneath the registers or flues and mixing-dampers provided for regulating the temperature. If there are large windows, flues should be arranged to open in the window-sills, so that a sheet of warm air may be delivered in front of the windows to counteract the effects of cold down-draughts from the exposed glass surface above. These flues may usually be made 3 or 4 in. in depth and should extend the full width of the window. Small rooms, such as vestibules, library, pastors'-room, etc., are usually heated with direct radiation.

Rooms which are used during the week are often connected with an independent heater so that they may be warmed without running the large boilers, as would otherwise be necessary.

In large buildings where a fan is used, it is desirable, if possible, to deliver the air to the auditorium through a large number of small openings. This is best done by constructing a shallow box or chamber under each pew, running its entire length and connecting with a plenum space or with distributing ducts beneath the floor.

This connection may be either at the center or ends of the pew as most convenient, and should be concealed in the woodwork by thickening the supports or legs. By this method the air is delivered at a low velocity through a long slot, as shown in Fig. 1.

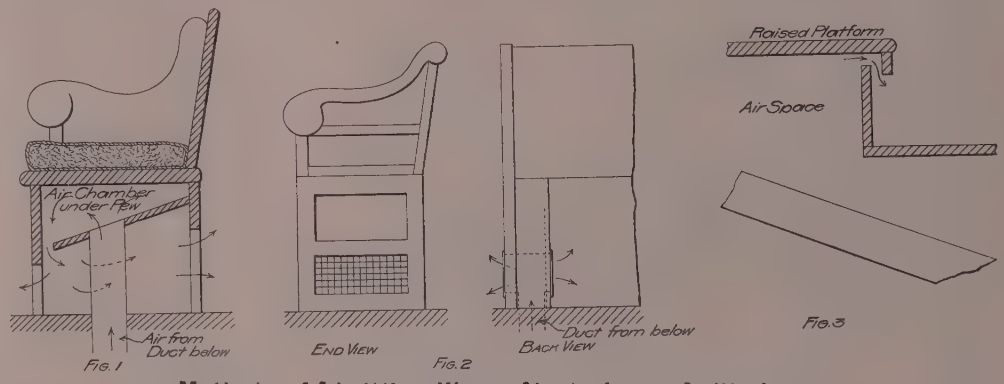
If the auditorium has a sloping floor, a plenum space may be provided between the upper or raised portion and the main floor.

Sometimes a shallow basement 3 or 4 ft. in height, with a cemented floor, and extending under the entire auditorium, is used as an air space. If the basement is of good height and used for storage or other purposes, it is necessary to carry large galvanized iron ducts at the ceiling under the center of each double row of pews, and connect with each pair by means of branch uptakes. The size of these uptakes should be equal to about 3 or 4 sq. in. for each occupant. When the lower part of the church is occupied by finished rooms the problem of a sufficient plenum space beneath the auditorium floor becomes more difficult, but even then it can often be provided by the use of a false ceiling placed 18 to 24 in. below the main ceiling of the basement. Another method of supply is to deliver the air through small registers in the ends of the pews near the floor, as shown in Fig. 2. This simplifies the pew construction somewhat, but otherwise is not so satisfactory as the preceding arrangement.

When the air-supply is introduced through the pews, discharge ventilation should be at the ceiling instead of through vents at or near the floor as in furnace or indirect gravity heating.

When the air enters through a comparatively small number of registers of large size, the greater part rises to the ceiling and is diffused through the upper part of the room. As it cools it falls slowly toward the floor, fairly well distributed throughout the church.

In reality, the supply to the central portion is by means of downward currents. Under these conditions the exhausted air should be discharged through openings near the floor. When a fan is used, and the supply is through each pew, the conditions are changed, for there is a slow upward movement of a practically solid volume of pure air throughout the entire room, which, after passing the breathing line of the audience, continues upward and is taken off at the ceiling. If the special pew construction is too expensive, or for any other reasons cannot well be used, and the fan is to be retained, the greater part of the air is best introduced through wall registers placed about 8 ft. above the floor, with exhaust openings at or near the floor.



Methods of Admitting Warm Air to Large Auditoriums.

By this arrangement the air is thrown horizontally toward the center of the church, and much of it falls to the breathing level without rising to the upper part of the room. Diffusers of some inconspicuous design should be placed over the inlets to prevent uncomfortable drafts upon the heads of the audience directly in front of them.

Exhaust fans are seldom employed in church work except in special cases. With furnace and indirect-steam systems heated flues are relied upon to produce the necessary draft. When a supply fan is used the pressure caused within the auditorium will force the air outboard, if the necessary outlets are provided. Ceiling vents should be gathered by means of galvanized iron ducts into central chambers connected with suitable roof ventilators well protected against back drafts.

Dampers should always be placed back of the ceiling vents, with means for operating them from the auditorium or gallery floors.

Velocities of about 500 ft. per minute may be counted upon for the passage of the full volume of air supplied to the auditorium through the ceiling vents.

As the church service is usually only an hour in length, and the cubic contents of the room large in proportion to the number of occupants, an air-supply of from 1,000 to 1,200 cu. ft. of air per hour per occupant will generally be found sufficient. If the church is warmed by air rotation up to a temperature of 65° to 68° before service, and then fresh air from out of doors is delivered at the same temperature during the service, the heat generated by the audience will usually be found sufficient to keep the room warm in all ordinary winter weather. This makes it possible to use a smaller main heater than is the case in other buildings where the floor-space is less closely packed.

A heater capable of raising the full volume of air to 75° or 80° in zero weather is usually sufficient. It is often desirable to keep the auditorium moderately warm during the week without running the fan. This may be done by providing a separate system of indirect stacks placed beneath floor registers located at inconspicuous places around the room. These heaters may take their air directly from the basement, which in turn should be connected with the room above either by special openings or by the use of stairways and open doors.

When the fan is running, these registers should be closed, unless it is desired to utilize the heaters in warming up the auditorium before service.

A fan run by a direct-connected motor at a comparatively low speed is preferable for this class of work on account of its quietness of action. The warm-air flues in the window-sills should be retained if the windows are large, but may be made narrower, if a fan is used, owing to the higher velocity of the air; slots 1 in. in width are usually sufficient for this purpose. Heaters should be placed at the bottom of the window flues to raise the air to a temperature of 110° to 120°.

Halls.—The treatment of a large audience-hall is similar to that of a church, and such hall is usually warmed in one of the three ways already described. When a fan is used, the air is commonly delivered partly through registers in or near the floor, and partly through those placed in the wall about 8 ft. above it, depending upon the arrangement and general construction of the building. They should be made of large size so that the velocity of the entering air shall not exceed 200 or, better, 150 ft. per minute over the whole area of the register face, in order to avoid draughts. If diffusers are used over the wall registers, velocities twice the above may be allowed. Where there are raised floors, as in a balcony, the air may be forced into the space beneath them and be delivered through openings in the risers, as shown in Fig. 3. A part of the vents should be placed in the ceiling and the remainder near the floor; the latter being especially for summer use or in case the room becomes overheated. All ceiling vents, both in halls and churches, should be provided with dampers having means for holding them in any desired position.

If indirect gravity heating is used, it will generally be necessary to place heating coils in the vent-flues for use in mild weather; but if fresh air is supplied by means of a fan there will usually be pressure enough in the room to force the air out without the aid of other means. When the vent airways are restricted, or the air is impeded in any way, electric ventilating fans are often used. These give especially good results in mild or heavy weather when natural ventilation is sluggish. The temperature of the room may be regulated by varying the number of sections in use in the main heater or by the use of a by-pass damper which allows part of the air to pass around the heater instead of through it.

One of the best arrangements is a combination of these two methods. A rough or partial regulation may be obtained by manipulating the steam valves and a finer adjustment by the use of the by-pass damper. For the best results the latter should be operated automatically by a thermostat placed in the hall. After an audience-hall is once warmed and filled with people, very little heat is required to keep it comfortable, even in the coldest weather. The air-supply per occupant may be taken about the same as for a church.

Theaters.—In designing heating and ventilating systems for theaters, a wide experience and the greatest care are necessary for the best results.

A theater consists of three parts: the body of the house, or auditorium; the stage and dressing-rooms; and foyer, lobbies, corridors, stairways and offices. The only satisfactory way of warming and ventilating the auditorium is by the use of a fan, and the most approved method of air distribution is to force it into closed spaces beneath the floors, and allow it to discharge upward among the seats in a large number of finely divided streams, one of the best arrangements being through chair legs of special latticed design, which are placed over floor-openings of about 4 sq. in. for each leg. In this way the air is delivered to the room at a low velocity without drafts or currents and is thoroughly diffused among the audience. In small theaters where the expense must be kept as low as possible, the arrangement already illustrated in Fig. 3 may be used to good advantage wherever raised floors or risers occur.

The discharge ventilation should be largely through ceiling vents, assisted by the use of exhaust fans. Vent openings should also be provided at the rear of the balconies, either in the wall or ceiling. The exhaust fans may be placed either in the attic or basement, as is most convenient. The close seating of the occupants produces a large amount of animal heat, which is usually sufficient to increase the temperature of the room 8° to 10°, or even more; so that in considering a theater once filled and thoroughly warmed, it becomes more a question of cooling than of warming.

The temperature of the air-supply to the auditorium is regulated at the fan, the same as in the case of churches and halls.

The dressing-rooms should be provided with a generous supply of fresh air, sufficient to change the entire contents once in 10 minutes at least, and should have discharge flues of sufficient size to carry away this amount of air at a velocity not exceeding 300 ft. per minute, unless connected with an exhaust fan, in which case the velocity may be doubled. In order to maintain a constant air supply, the temperature of the room is usually regulated in some independent way. This is usually done by means of direct radiation.

The foyer, corridors, etc., are generally heated by direct radiators which may be concealed by ornamental screens, if desired. Where offices are connected, they may be treated in a manner similar to rooms of like kind in other buildings.

The air supply for theatres may be taken at 1,200 to 1,500 cu. ft. per hour per occupant.

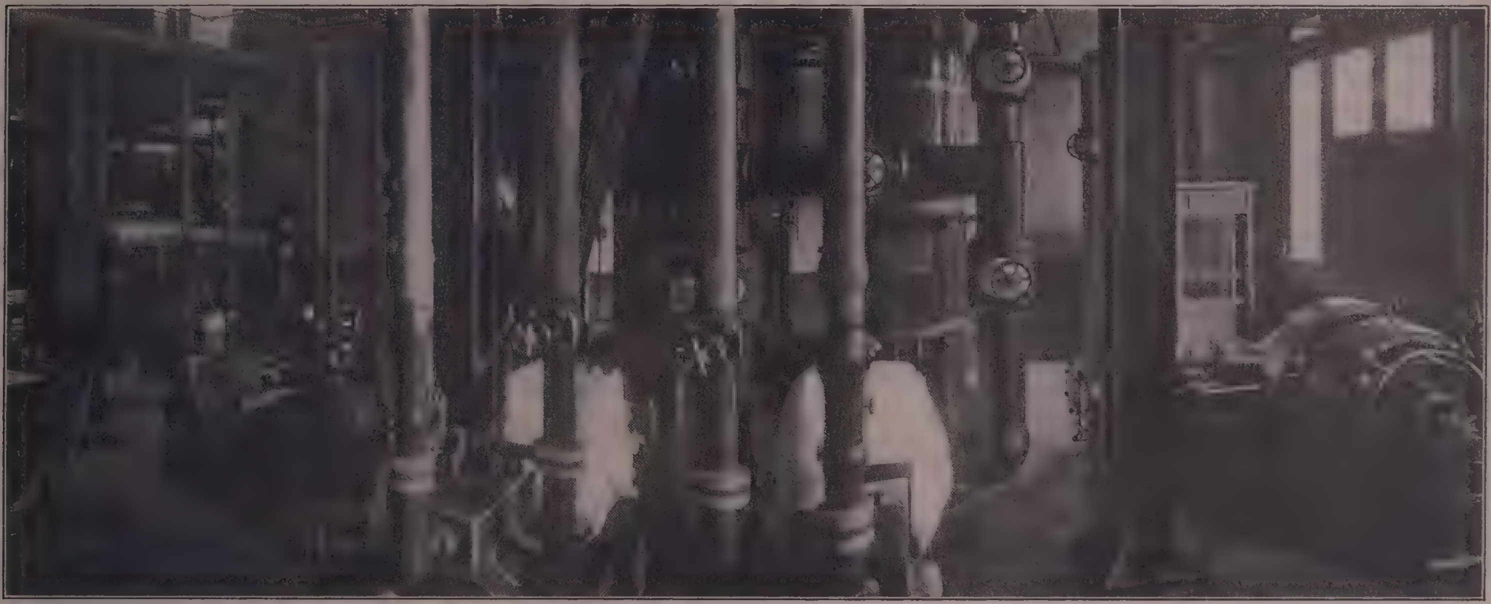
Railings on Highways are required, according to decisions of the Massachusetts Supreme Court, "in the case of bridges, embankments, or causeways, and generally where excavations, deep water, etc., are so near to the line of public travel as to expose travelers to unusual hazards." This has recently been reaffirmed by the court in an action against the people of Shelburne by a man who had an unusual accident. He was driving a blind horse over a narrow bridge with which he was familiar. He was holding the reins in one hand and adjusting the laprobe with the other, when the horse went off the bridge and the damage happened. The court ruled that the driver's conduct was fairly incidental to the ordinary use of public ways by travelers in carriages, and the award of damages to him by the trial court on account of neglect to fence the bridge was affirmed.

Description of a Cold Storage Plant Utilizing Exhaust Steam.

A paper read before the December meeting of the American Society of Refrigerating Engineers by Mr. Henry Torrance, Jr.

The purpose of this paper is to show what can be done in cold storage warehouses every day with the absorption system of mechanical refrigeration in practical operation, using exhaust steam from the auxiliary machinery The plant described is that of the L. C. Bates Co., New Haven, Conn. The original cold storage plant was built in 1892. The original warehouse, still in use, contains about 140,000 cu. ft. of space, measured inside the insulation, including the ante-rooms. The insulation was built of boards, paper and sawdust, in all about 10 in. thick. About one-third of the house is made up of freezing rooms and the balance contains rooms held at 30° to 40°.

A 15-ton absorption machine was installed, with horizontal tubular boiler, duplex water pump, duplex brine pump and duplex boiler feed pump, single cylinder ammonia pump, and a 15-h.-p. vertical engine for running the elevator and dynamo. During the thirteen years of operation since its completion, from 1892 to 1904, inclusive, the brine was generally held at 5° and the freezers at 15°. The coal consumption in summer was about 1.8 tons per day, all exhaust steam going to waste.



Absorber, Ammonia Pumps, Brine Pumps and Cooling Tanks, Electrical Generator.

Absorption Refrigerating Machinery Equipment of Mr. L. C. Bates Cold Storage Plant.

In the winter of 1904 the entire old refrigerating plant was taken out, a new plant, consisting of two 25-ton machines, as described below, was installed in a new building, and this machinery was used in 1905 to cool the old building. The coal consumption for the months of June, July and August, 1905, was 25 gross tons per month, or an average of 0.83 gross tons per day. The brine was carried at about 15° below zero, and the rooms maintained from zero upwards. Thus a little more work was done with the new plant in 1905 than with the old plant in 1904, and with a little less than one-half the coal, showing a saving of over 50 per cent.

In the winter of 1905 the new warehouse was completed and added to the system. It has eight floors 10 ft. high, 6½ being insulated with 4 in. of Nonpareil sheet cork finished with cement and each containing 3,100 sq. ft. of floor area, measured inside the insulation, making a total of 201,000 cu. ft. One room was shut off so the total space cooled was as follows:

Year.	Machinery used.	Space cooled (about ⅓ freezer).	Tons coal per day.
1892 to 1904	Old plant	House A, 140,000	1.8
1905	New plant	Same.	.83
1906	New plant	House A, 140,000	
		House B, 190,000	1.3
		Total, 330,000	

The following is a list of the rooms, with the temperatures maintained on July 3, 1906, which shows average conditions:

WAREHOUSE A.		WAREHOUSE B.	
Room.	Temp.	Room.	Temp.
21	37°	81	35°
34	37°	82	32°
23	36°	31	30°
41	36°	51	30°
43	34°	61	30°
51	34°	71	30°
35	30°	32	4°
42	30°	41	0°
44	30°	42	8°
52	29°		
32	23°		
22	17°		
33	6°		

The coal used during the summer of 1906 was 203.4 gross tons, the coal bought during the various months of the season amounting as follows: May, 51 tons; June, 52 tons; July, 48.3 tons; August, 28.9 tons; September, 23.2 tons. The total number of days from May 1 to Sept. 30 was 153, so that the average amount of coal used per day was 1.33 tons. This fuel was bought as Cumberland soft coal.

The refrigerating plant consists of the following equipment: One horizontal tubular boiler, 72 in. x 17 ft., set in brickwork; one horizontal tubular boiler, 54 in. x 13 ft.; an iron flue connecting both boilers to the stack; two 25-ton special absorption refrigerating machines of the closed type; two direct-acting steam ammonia pumps, each 10 in. x 4 x 10 in.; two duplex brine pumps, each 10 x 8½ x 12 in.; one duplex water pump, 7½ x 6 x 8 in.; one duplex water pump, 10 x 8½ x 12 in.; two single-cylinder boiler feed pumps, each 6 x 4 x 8 in.; one 50-h.-p. Harrisburg automatic engine, 11 x 10 in., with direct-connected dynamo running 300 r.p.m.; two elevators; one 5-h.-p. electric motor for fur-room fan; one Utility feed-water heater and purifier; one damper regulator, and two Anderson steam traps for generator drips.

The boiler pressure was generally kept at 90 lb., and a 4-in. steam pipe conveyed steam to each of the four pumps and to the engine. The exhausts of all these pumps and the engine were joined together and run into the oil-separating compartment of the Utility tank, generally under a pressure of about 5 lb., and the boiler feed pump delivered water to the boiler hot, generally at a temperature of 200°. To supply the leakage of steam and waste from the oil separator, drips, stuffing boxes, etc., enough fresh water was fed daily into the boiler to raise the level about 12 in., as shown by the gauge glasses, which seemed to be sufficient to maintain the proper level. This water was fed in slowly during the day time, but none whatever was fed in during the night. For this reason the boiler remained free and clear from scale.

The duplex water pump draws water direct from the wells at a temperature of about 56° and delivers it to the refrigerating machines, the waste water running to the sewer. City water was used in the boilers, and, as mentioned above, the quantity was nominal; as a matter of fact, the city water bill with the new house was very much lower than the water bills were formerly with the old plant.

Lead Joints in Gas Mains resisted the earthquake on April 18 at San Francisco in a satisfactory manner, and nearly 65 miles of high-pressure steel mains with such joints remained intact. Mr. E. C. Jones, of the California Gas & Electric Corporation, attributes this solely to the fact that lead was used rather than cement for jointing.

Operating Experience with Four-Stage Curtis Turbines.

The Union Electric Co., of Dubuque, Ia., has been using five four-stage 500-kw. Curtis turbo-generators for some time, and the operating experience gained during this period has been summarized in a paper read before the Iowa Electrical Association by Mr. C. E. Stanton, the chief engineer of the company. He first took up the apparatus used in connection with the step bearings.

All step-bearing water passes first through a Jewel filter, thence through the pumps to the strainer in the baffler casting and thence through the baffler direct to the step-bearing. By its passage through the baffler the pressure of the water is reduced, so that the actual step-bearing pressure is from 180 to 200 lb. per square inch. All shock or pulsation of the step-bearing pumps is also eliminated by the baffler. As the step pumps and the service pump which supplies the water used in the former are packed with a fibrous packing, it was soon found necessary to keep a record of the safe life of this packing, as if left in until it began to lose its elasticity and get soft, small particles and strings of packing would find their way into the strainers, and would soon plug them, thereby cutting off the water supply to the step. On the step pumps which work against a pressure of 400 lb. per square inch, the safe life of the packing is sixty days. On the service pump against 50 lb. pressure, the safe life of the packing is four to five months, depending on the condition of the river, whether muddy or not. If dirt or pieces of packing get into the step-bearing pipe system, it is uncertain when they will find their way into the strainers, it may be hours, days or weeks. This uncertainty is far from pleasant, because if there is enough loose packing in the system it can at any time plug the strainers, thus cutting off the water supply to the step bearing. All strainers are taken out and cleaned every twenty-four hours.

After nine months' service it was noticed that the pumps were running much faster than at first, to do the same amount of work. An examination showed that the water valves and seats were cut quite badly, and nearly all the way around, with shallow grooves, mostly, although some spots looked, as far as their shape was concerned, more like corrosion than anything else. A tool was made to true up the seats in place and the valves were faced off in a lathe; with a slight grinding with emery dust they were in good condition again. It was thought that as these valves should open and close positively with each stroke of the pump, they should not cut so quickly or as badly as they did. Close examination showed that a close hard scale had formed on all valves and seats, and this seemed to hold the valves slightly away from their seats. This wire drawing of the water (if it can be so called) was thought to be the principal cause of the cut valves. They are now cleaned free from this scale each week.

The hydraulic accumulator, which is connected into and forms a part of the step-bearing piping system, and which acts as a reserve in case of the temporary stoppage of the step-bearing pumps, is tested every twenty-four hours. To test the accumulator, the throttle on the step-bearing pump is closed tightly, as the step pumps are run just fast enough to keep the accumulator up. This slight closing of the pump throttle allows the accumulator to drop slowly, four or five feet every day. As there are always one or more turbines in operation, and as just pressure enough is carried on the step-bearing pumps (400 lb.) to keep the accumulator raised, if it was not for the test each day, it would always be up and would finally rust fast and would not come down, even if all pressure was removed from the pipe system which holds it up, thus defeating the object for which the accumulator is used. It is known by experience that the accumulator will stick, if not tested often. The ram or piston of the accumulator is 9 in. in diameter, and the bored part of the cylinder, which acts as a guide to steady the accumulator when raised, is about 36 in. in length. As this bored part is a close working fit on the ram and the water is always in contact with it, the nicest kind of a rust joint will finally form between the ram and the bored hole around it.

One other precaution, which is usually taken in connection with accumulators for this work, is some kind of signal, usually a steam whistle, which will blow if the accumulator starts to come down. Something of this kind is necessary, as without it, if the step pumps should slow down, and there are many reasons why they should do so, the step pressure might get so low as to be dangerous and injure the step.

As the step bearing, with its very thin film of water, under pressure has to support the weight of all the revolving parts of the turbine, wheels, shaft, field, etc., it is a very important part, and cannot be examined too closely while being assembled. Under the bottom half of the step bearing is the adjusting screw; this screw is vertical and in exact alignment with the turbine-shaft center. The end of this screw, on which the step bearing and all the revolving parts of the turbine are carried, must be exactly square with the axis of the screw—a burr or dirt here means trouble, as it will throw the step out of its true alignment. This is also true in regard to the top of the upper step plate and the bottom of the turbine shaft, which rests in a socket or recess in the top of this plate. In the bottom of the turbine shaft are drilled two guides or dowel-pin holes. A key way is also cut across the bottom of the shaft, the guide pins and key are made fast in the top of the upper step-bearing plate, and are an easy fit in the shaft, if all surfaces are clean and all burrs, scratches, etc., removed.

If through any cause the step plate should bind, either from dirt, abrasions, or a bad fit, and it should be forced up in place, the chances are that it would not be square with the shaft. The turbine would then have a tendency to vibrate, and might not run right until this fault is corrected. The bottom step-bearing plate should be an easy fit in the casting which holds it and the adjusting screws in place; it should drop of its own weight into its socket or recess and should not bind or have to be forced to its set. Both step plates should be of exactly the same diameter and should line perfectly. The recess in the plates, from which the step-bearing water is forced out between the faces of these plates, should also be of exactly the same diameter and depth. The edges of the recess should also line perfectly, as if they were not in line a fin might form around one side of the recess, which would cause an unequaled flow of water from the step and have a tendency to cause vibration.

If for any reason it is desired to grind the step bearing in place, it can be done very easily, and without any trouble whatever, by gradually closing the stop valve between the step-bearing main pressure pipe and the step bearing. By listening at the step bearing and watching the step-bearing gauge while very slowly closing the stop valve, any degree of pressure can be had between the two bearing faces of the step. It should be borne in mind that the greater the speed of the turbine while grinding the step, the faster the faces will grind, and the more damage would be done if the stop valve was closed enough to let the steps together hard.

Directly above the step bearing is the steady or guide bearing. This is a bronze shell, flanged on one end, lined with babbitt metal, and bored about 0.006 in. larger than the shaft. It is held in place by stud bolts through its flange; these studs are outside of this sleeve is tapered and fits in a corresponding tapered hole in the base of the turbine. Before this bearing sleeve is put in place, it screwed into the bottom of the turbine base. The should be thoroughly cleaned and examined for any rough spots. If it should not seat perfectly all around when in place, it will work loose; screwing up on the nuts will not hold it. At the Dubuque station there have been two or three loose steady bearings, and in each case the trouble was found to be due to dirt, bruises or metal chips, which would not allow the bearing to seat properly. The first turbine started in the plant, which had done all of its share of the work for about one year, had the original step bearing and guide sleeve still in place, which was apparently as good as ever when Mr. Stanton prepared his paper.

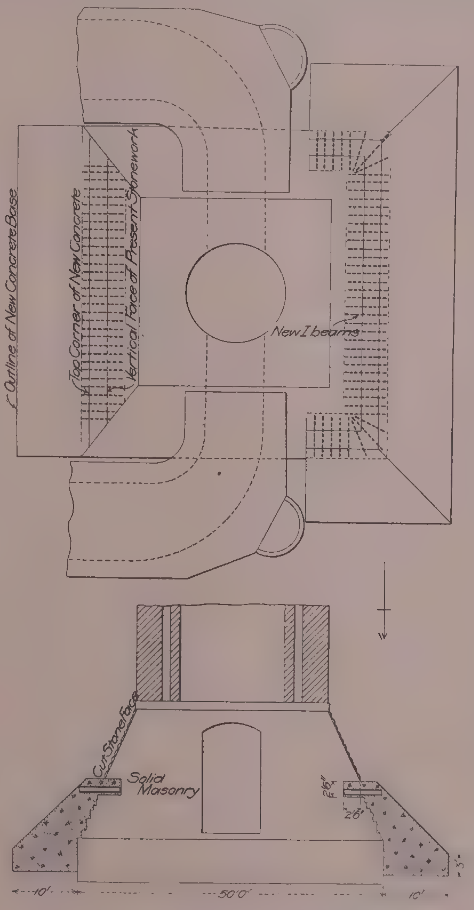
There are eight main nozzle valves, each with its individual pilot valve, which is electrically controlled. The pilot valves control the action of the main-nozzle valves. On any load within the rated capacity of the turbine, running condensing, five valves are all that will open, leaving three valves which might not open for days at a time. If these valves are left alone they will corrode and stick, and if a heavy overload should come on might not open at all, or if they did open they might stick open. In this case, if a short-circuit should open the breakers, the turbines would run away, causing the safeties to act and shutting off the steam supply to the turbines. This would cause considerable more delay in getting current back on the line again. If the main valves are packed too tight, or if the pilot valves leak, the main valves may stick. To obviate these troubles all valves are opened and closed several times each day when starting turbines. As the pilot valves are electrically operated, and as they govern the action of the main-nozzle valves, all that is necessary is to make or break the electrical contact for each valve in testing, and the valves, if kept in proper condition, will thereupon open and close promptly.

The close regulation of the turbines was a surprise to some who had spent many years in charge of belted and direct-connected engines and generators. It was the original intention to use separate turbines and bus-bars for the commercial lights, but this has not been found necessary. Everything, railway, power and lighting, has been supplied from one set of bus-bars, and there has been no trouble with the regulation of lights or turbines.

A suitable packing for the main nozzle valves was at first hard to find. A kind of string metallic packing was first used which had proved successful on lower steam pressures, but it would melt here, as 190 lb. of steam and 150° of superheat were too much for it. Another kind of metallic packing, guaranteed to stand any degree of superheat was then tried. This seemed to be made of small metal chips and graphite, and was supposed to form a well-lubricated metallic ring which would last for months. In use, however, the chips of metal would get under the pilot and main valves holding them open. All valves had finally to be taken out and cleaned. In cleaning the stuffing boxes all that was found of the packing was a lot of loose metal chips. The best asbestos ring packing that can be obtained is now used and it is the practice to pack the valves more often than expected with the metallic packing.

The middle bearing is made in halves, of cast iron, babbitted and bored out about 0.01 in. larger than the shaft. Extra large oil grooves are cut in both middle and top bearings; they run in a bath of oil, and with a greater circulation of oil through the bearings than would be possible with any other type of bearing with which Mr. Stanton is familiar. The top bearing is a cast-iron shell flanged on one end, babbitted and bored about 0.01 in. larger than the shaft; it is clamped in place by bolts through the flange, if it is a solid bearing. Both solid and spring bearings have been used for the top and middle bearings. At first all bearings were solid; at present both top and middle bearings are of the spring type. On two turbines the springs have been renewed several times; on one once or twice; on the fourth, or rather the first one supplied with spring bearings, the first bearings put in were still in use after six months' service when the paper was written.

Gravity oil feed is used on all turbines, and the bearings are so constructed that there can always be a strong circulation of oil through them. From the turbines the oil flows by gravity to the oil-cooling and separating tank, then through the oil filter to the suction tank, from which the oil pumps take the oil and pump it into the gravity-oil-feed tank, which is perhaps 25 ft. above the turbines. From this tank the oil flows to the turbines, then to the cooling tank, and over its same route through the filter, etc. A valve is so placed that when closed it cuts the oil off from the gravity-oil tank and puts the full force of the oil pumps on the oil-feed line. This valve proved to be the station's salvation several times. With three or four turbines on, the oil would suddenly stop running on the turbines. The only thing left to do was to partially close the valve on the delivery pipe to the gravity-oil-supply tank, putting the oil pump directly on the oil-pipe system, when, of course, the oil had to come if the pumps were in order. It was finally decided that air must trap in the gravity-oil tank, and getting into the oil-feeder pipe line interfere with the flow of oil. This would cause an intermittent flow at certain times, of which there was no indication until the supply of oil was shut off. That this was right has since been proved by the remedy, which was to vent the top of the tank by a ½-in. pipe 4 or 5 ft. long, with the top bent over in the form of a goose neck.


Outline of New Concrete Base
Top Corner of New Concrete
Vertical Face of Present Stonework
New I beams
Cut Stone Face
Solid Masonry
2'6"
2'6"
3'
10'
50'0"
10'

Plan and Elevation of Extended Chimney Footing.

Straightening a 250-ft. Chimney.

An unusual method of foundation reinforcement was recently adopted to stop the settlement and straighten a large brick stack at the Detroit, Mich., works of the Solvay Process Co. The chimney is a 250-ft. circular brick with an interior diameter of 20 ft., which serves the boilers of the power plant of the works. The foundation as originally built was of concrete, about 50 ft. square, resting on clay at a level about 16 ft. below the surface. Above this the solid masonry base of the stack rises to a point about 10 ft. above the ground where the brickwork commences. Two years after the erection of the stack, it had settled over one foot, one side about 6 in. more than the other. As it appeared probable that further settlement would follow, Westinghouse, Church, Kerr & Co. were called in as engineers to suggest a method of stopping further settlement, and, if possible, realign the structure. After examination, the following method was adopted, and it has been carried out in all essential particulars.

The foundation was found to have a bearing area of 2,444 sq. ft. on a clay which, while of ordinary firmness, might admit of further settlement under the weight of the chimney. It was accordingly decided to spread the foundation somewhat on two sides, with the greater widening on the side which had settled the most, so that, if further slight settlement should ensue, it would tend to throw the stack back into a vertical position. This was accomplished by building extension footings of concrete outside the masonry foundation and bonding the extensions to the main structure by cutting slots into the latter just below the ground level, into which the concrete extensions were grouted with steel reinforcement, as shown in the accompanying drawings. The slots are about 2½ ft. deep by 2½ ft. high and the reinforcement planned was of 12-in. I-beams, about 6 ft. long, spaced on 16-in. centers. On account of material on hand some variation was made in the planned reinforcement, but its equivalent has been used.

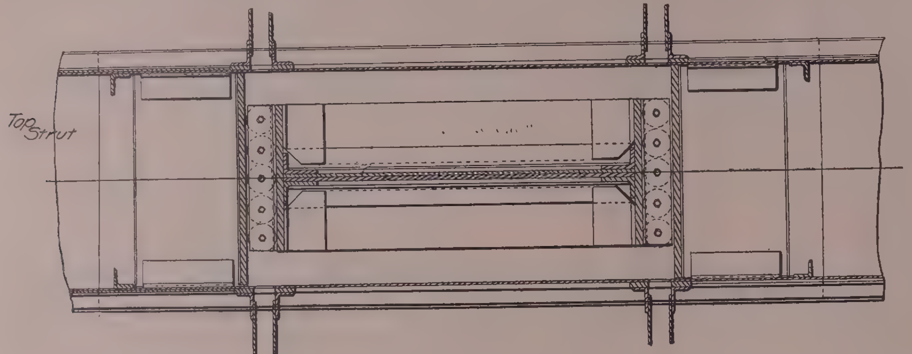
The concrete extension footings were installed with considerable care in sections 6 or 8 ft. long, the concrete being firmly rammed into place. The footings are 10 ft. in width at the base, and on the easterly side extend the width of the original foundation only, while on the westerly side, toward which the stack had leaned, they were carried the full length of that side and around at the ends for a considerable distance. The total area of new footings planned was 1,480 sq. ft., of which the section on the westerly side had an area of 970 sq. ft., and that on the easterly side an area of 510 sq. ft.; the remainder on this side has been omitted for the present to give the chimney a chance to settle back plumb, after which the footings upon the easterly side may be increased to the extent planned, or even more. The total bearing area of the extended foundation is now 3,414 sq. ft.

The expectation of the engineers has been fully realized and the chimney now stands secure. So far as can be discovered in the time that has elapsed, the high side is yielding slightly, and in time, though some years may be required, the chimney will eventually become plumb and the additional reinforcement work be then executed.

A Landslip has been continuing for some time at Albany, N. Y., on a street on a sidehill underlaid by blue clay. The lots on one side were brought to grade with ashes and rubbish, with a slope of 1 : 1, on which the clay from street grading was recently dumped. Soon afterward the slip became more evident, and increased rapidly as soon as the water service pipes were torn apart. The settlement is now about 6 ft. and has ruined many buildings.

Adjustable Connection of Anchor-Arm Lateral System, Quebec Bridge.

The general design of the anchor-arm of the Quebec bridge was illustrated in this journal on Dec. 1, and it is proposed in this article to describe the adjustable connection of the lateral system in this arm. The assumed wind pressure of 500 lb. per linear foot on the upper part of the superstructure is carried by the top lateral system of transverse struts and X-braces, and is transferred from it to the sub-structure through the vertical bent on the main pier and through the portal at the shore end where the stresses from the bottom lateral system and the floor system unite and are combined directly with those from the upper system. At the opposite end of this span, the wind stresses from the floor system are transferred through the vertical bent like those of the upper system and are combined at its foot with the stress from the lower chord system, and their resultants are transmitted directly to the masonry through fixed connections, the superstructure being rigidly attached to the sub-structure at this point.



Roller Bearing of Tenon Girder in Transverse Strut.

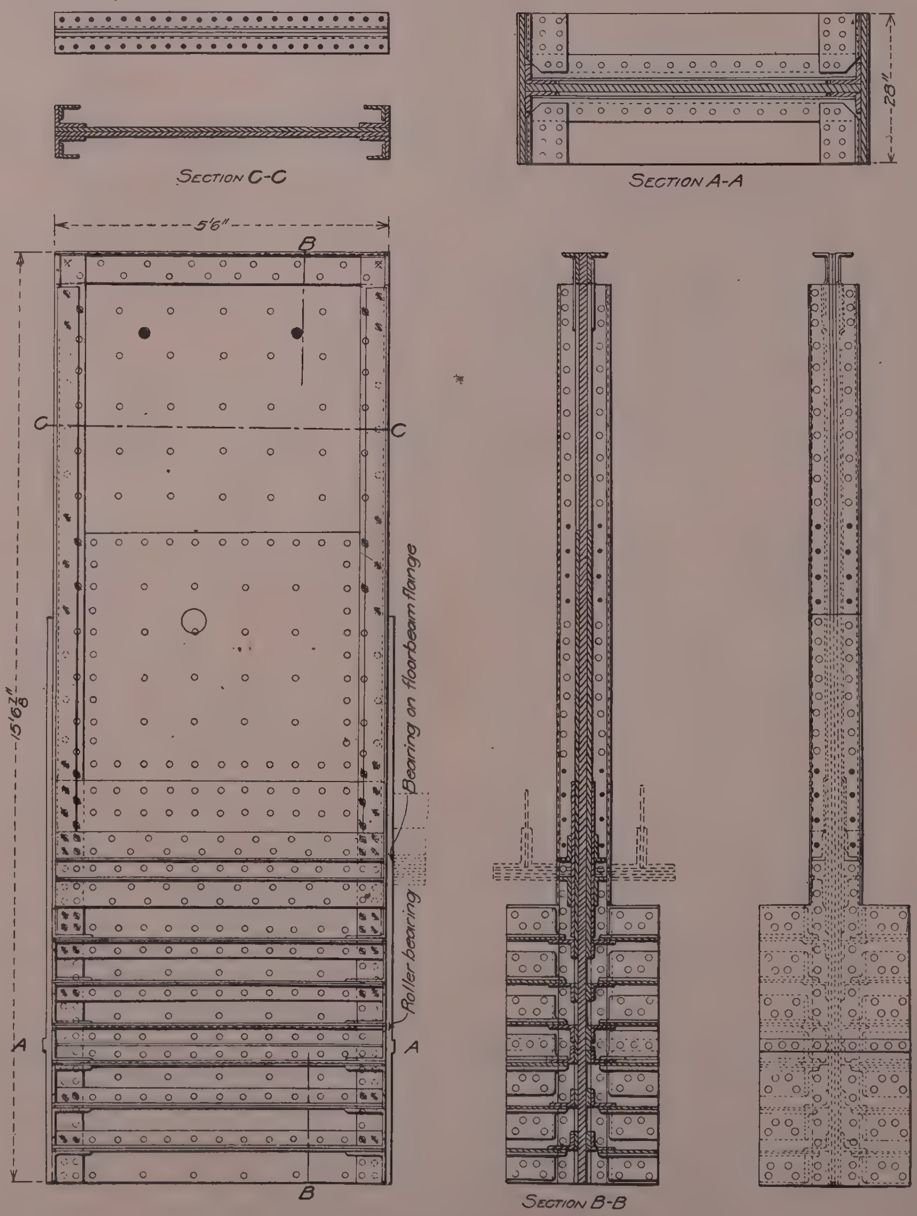
At the anchor pier provision is made for a longitudinal movement of about 4 in. in each direction, to provide for the expansion and contraction of the superstructure on the fixed upper end of the transverse bent connecting the extremity of the lower chord with the top of the masonry. The maximum combined horizontal transverse wind stresses in either direction at the top of the anchor pier are 1,010,000 lb., which must be transmitted from the end floorbeams of the anchor-arm span to the transverse tower bent and through it to the masonry pier without interrupting the relative displacement between the two parts of the structure. The tower bent, as shown in the general elevation of the span published on Dec. 1, consists of a single X-braced panel with massive vertical members which do not support any dead or live load from the superstructure, but serve merely as a case enclosing the anchorage eye-bars and to transmit the vertical component of the wind stress to the top of the pier. The end floorbeams have a special connection at their center point to the top transverse strut, which units the vertical posts in the pier tower and to which their total stress is transferred, producing equal components of 783,500 lb. in each of the diagonals and vertical components of 596,500 in each of the vertical posts.

It was at first proposed to provide lugs on the lower flange of the end floorbeams and on the top flange of the tower strut which should engage each other with sliding longitudinal bearings; this detail was superseded by one which provides deep vertical roller bearings for the contact between the floor system and the tower. This is accomplished by a massive vertical girder rigidly attached to the center of the floorbeam, projecting inside the top strut of the tower where it is free to move longitudinally with continuous bearing on its opposite flanges against vertical rollers seated on beds which receive the heavy stress and transfer it to the top strut.

The end floorbeam, about 62½ ft. long and 10½ ft. deep over all, is connected to the truss by 49 ⅞-in. field rivets and 35 turned bolts through vertical angles at each end. It has two 7/16-in. webs 33 in. apart on centers, and two flanges made of pairs of 8x6x¾-in. angles, and 13x⅝-in. cover plates, thus making essentially separate plate girders with their top and bottom flanges connected by tie plates and lattice bars. The webs are connected by four vertical diaphragms parallel to the bridge axis and symmetrical about the center line of the girder; the main diaphragms are spaced 3 ft. 3 in. and 9 ft. 9 in. from the center line of the floorbeam.

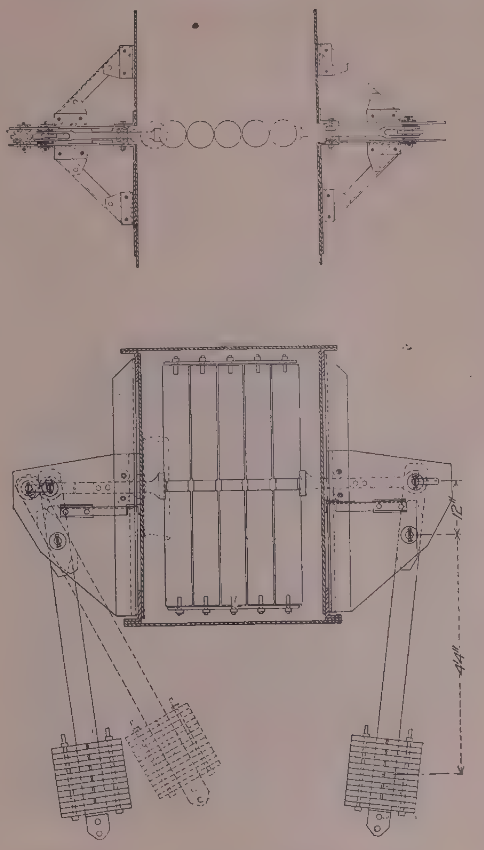
All of the diaphragms have I-shaped cross-sections made with a web plate and four flange angles, and are shop-riveted between the halves of the girders. Between the diaphragms on each side of the center line, the bottom flanges of the floorbeam are connected by ¾-in. cover plates 36 in. wide and 8½ ft. long, which project slightly beyond the center diaphragms and are reinforced by top and bottom cover plates planed on the end nearest the center to accurate bearing against the flanges of the vertical girder or tenon, the upper end of which passes between the floorbeam halves and is field-riveted through horizontal angles at the upper end to the 36x½-in. cover plate shop-riveted across the upper sides of the top flanges of the floorbeam between the two center diaphragms. Short diaphragms parallel to the floorbeam webs near the center and the lower flange are connected to the vertical flanges of the tenon girder by eight ⅞-in. bolts in each, access to which is provided by 6-in. hand holes in the webs of the floorbeam girders and diaphragms. This arrangement provides for the assembling and connection of the vertical tenon girder to the floorbeam after the latter had been erected in position.

The tenon girder, about 15½ ft. long vertically and 5½ ft. wide in the direction transverse to the bridge axis, projects about 5 ft. clear of the lower flange of the end floorbeam and is made with a web plate having a minimum thickness of 1½ in. composed of two 66x¾-in. full-size plates.



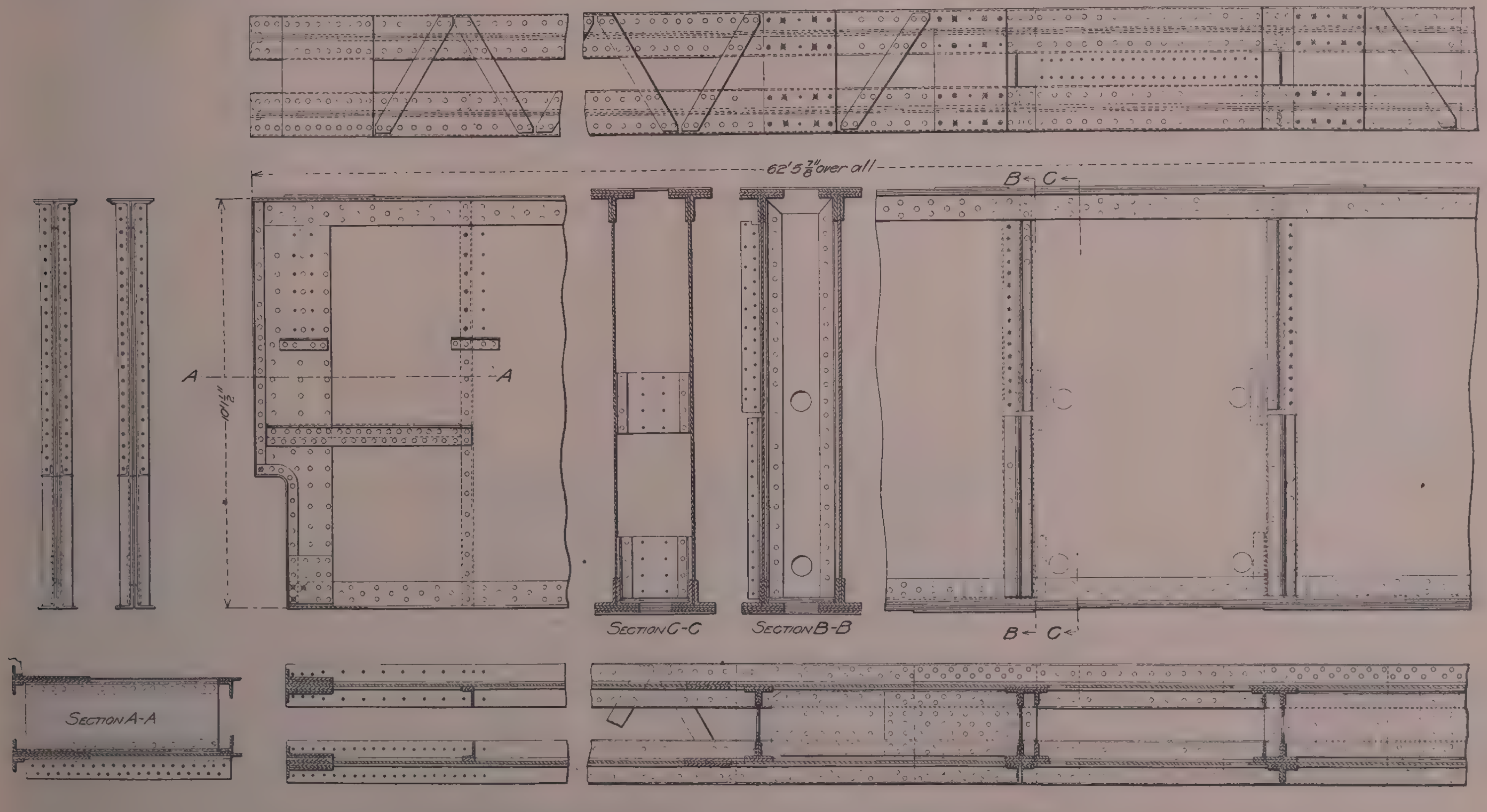
Tenon Girder and Anchor Pier.

These plates are riveted together throughout their entire length and width, and where they intersect the lower flanges of the floorbeams are reinforced to a total thickness of 4 in. The flanges of the girder are each made with two 4x3x½-in. angles with cover plates 1 11/16 in. thick and about 10 in. wide above the bottom flanges of the floorbeam. Below this point the cover plates are extended to a width of 28 in. and are planed to a thickness of 1¼ in. each side of a horizontal 2½x⅜-in. tongue in the middle of that portion which projects beyond the floorbeams. This part of the girder flange is reinforced by web stiffener angles and plates which virtually constitute a series of horizontal diaphragms 8⅝ in. apart connecting the lower ends of the opposite flanges and forming a very solid member to transfer the pressure on the bearings of the nests of vertical rollers which engage the tongues on the cover plates. The tenon girder weighs nearly 17,000 lb., and its flanges are planed to bear accurately against the finished surfaces previously mentioned on the ends of the bottom flange cover plates of the end floorbeam.



Automatic Counterweights for Roller Adjustment.

The top strut of the anchor pier tower is a box girder with two 60x½-in. webs, two 49x½-in. cover plates and four 7x3½-in. flange angles. The top cover plate is slotted at the center to receive the lower end of the tenon girder, which enters it with clearance as shown in the sectional plan. Each side of the tenon girder, the webs of the tower strut are connected by five horizontal diaphragms about 20 in. long. The inner ends of the diaphragms are faced to receive vertical 1¼-in. plates parallel with the axis of the bridge that have tongues planed to correspond with those on the cover plates of the tenon girders and with the latter form the bearings for the vertical friction rollers. The plates and diaphragms transmit the wind stress from the tenon girder to the tower strut and distribute it through both webs of the latter, whence it is transmitted to the vertical and diagonal members of the towers.



End Floorbeam Receiving Tenon Girder, Quebec Bridge.

Each nest consists of 5½-in. vertical rollers about 4½ ft. long assembled together with bolts tapped into both ends and engaging the cross-bars in the usual way. The rollers are supported by the tongues on the bearing plates and are free to move back and forth parallel with the expansion and contraction due to variations in temperature. In order to prevent cumulative displacements by successive movements in the same direction, they are provided with an automatic attachment to maintain them constantly centered with the struts when not in actual operation under wind stress. The apparatus for this purpose consists of a system of levers and counterweights arranged as shown in the cross-section of the tower strut. The outside rollers of each nest engage the vertical concave bearing on a movable horizontal arm parallel to the bridge axis. This arm is set on the center line of the roller and one end is carried between two pairs of horizontal transverse friction rollers and a pair of planed guide plates; the other end is pivoted to the upper end of the counterweight lever. The latter engages the horizontal pivot with a slotted hole and has a riveted support at the lower end for an adjustable counterweight composed of 65-lb. flat plates bolted to it. This arm is nearly 7 ft. long over all, and is set so as to make a small angle with the vertical when the rollers are in their central position, thus providing a constant lateral thrust against the rollers which increases to oppose their displacement in either direction. The fulcrum pivot is supported by a pair of angle brackets which enclose the levers and are riveted to the webs of the tower strut. The cast-iron counterweight plates are 1 in. thick, and are made in halves, slotted to clear the bar from which they are suspended and are secured by two vertical bolts through each piece.

Mr. E. A. Hoare is the chief engineer of the structure, and Mr. Theodore Cooper, consulting engineer. The contractor for the steelwork and erection is the Phoenix Bridge Co.

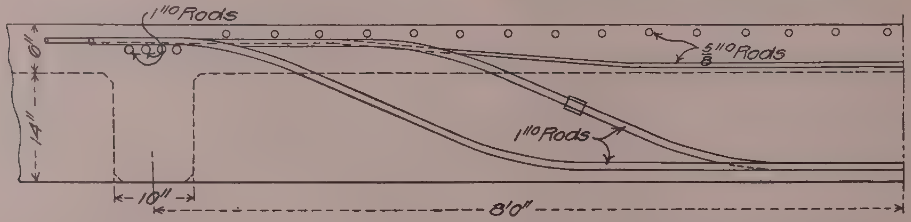
A Turbine Air Compressor.

A turbine air compressor of the Rateau type, built by Brown, Boveri & Co., has been tested thoroughly with results given in the "Schweizerische Bauzeitung." The machine was designed to give 35.3 cu. ft. per second at a pressure of 5 atmospheres when running at 4,000 r.p.m. In order to get this pressure it proved necessary to speed the compressor to 4,250 r.p.m., the discharge being 39.9 cu. ft. per second. The air was drawn from a large reservoir through a calibrated orifice, a gauge fitted to the reservoir showing the pressure inside it. The efficiency of the machine was 69.8 per cent. measured by the ratio of the work theoretically necessary to draw in, compress and deliver the air under the test conditions, to that actually expended on the compressor shaft. The efficiency on the basis of work necessary to compress the air isothermally to that actually expended is 61.5 per cent.

Unusual Details of a Reinforced-Concrete Floor.

In a 158x80-ft., three-story, reinforced-concrete warehouse, built by the Baker Manufacturing Co., makers of windmills, tanks and gasoline engines, at Evansville, Wis., a system of floor reinforcement, with unusual details, was used. The floor columns are on 16-ft. centers in both directions and are connected with beams 10 in. wide and 14 in. deep, measured from the bottom of the beam to the bottom of the 6-in. floor slab. The peculiarity of the reinforcement is that the rods in both floor beams and slab are connected in lines extending from side to side and end to end of the building. The beams have four 1-in. round steel bars, which pass over the tops of the columns near the upper surface of the floor slab and dip down toward the under surface of the beam near the middle of each 16-ft. span. The four rods are parallel through the section of greatest bending moment but in the shear section they separate and two run back toward the end of the span further than the others before turning upward, thus distributing the metal somewhat in the shear section. The floor slabs are reinforced in both directions with ⅝-in. round steel rods, 6 in. center to center. These rods are depressed to the bottom of the slab at its center and raised to the top of the slab over the beams. The rod couplings in both beams and slabs are arranged so as to occur in the shear sections. They are made of steel shafting, 1½ in. for the beam rods and 1-in. for the slab rods, bored and tapped to receive the threaded ends of the rods.

Bending the Floor Slab Rods.

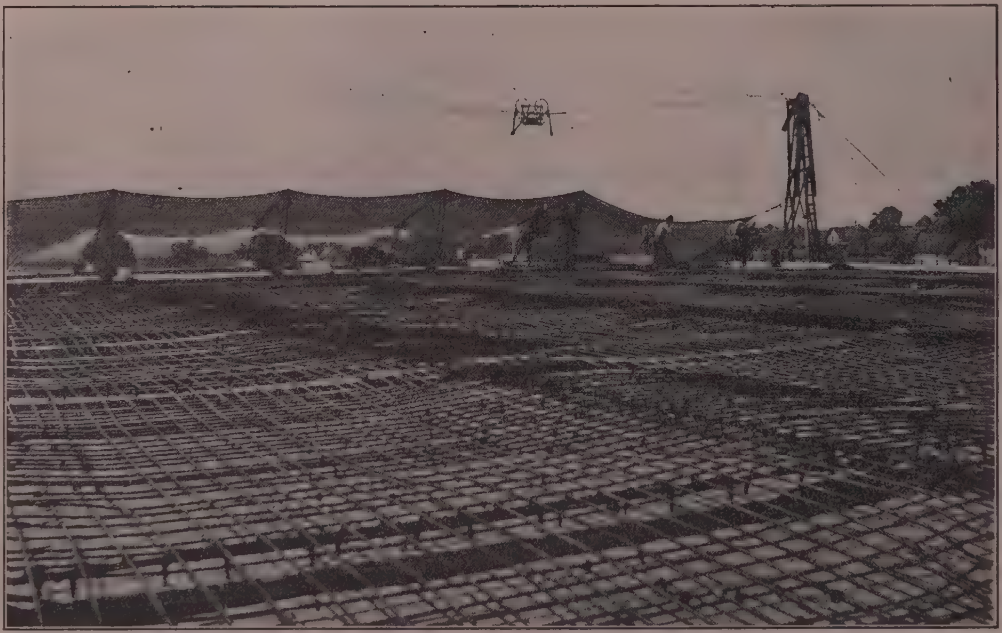


Section of Beam and Floor Slab, Showing Arrangement of Rods.

The 1-in. rods are coupled and bent before being placed in the beam boxes but the ⅝-in. rods are coupled while lying in place and are afterward bent with a special tool consisting of two vertical levers attached to a horizontal bar, the bearing points on the rod being a pin projecting from the horizontal bar and a wheel on the end of each lever, as shown in an accompanying illustration. It is operated by two men and makes two bends in a rod at the same time. As many as ten consecutive slab rods are coupled at once, a crank being used at one end to screw them up. Standard iron washers slipped on the ⅝-in. rods hold them away from the planking and above the beams they are held in place by little skeleton castings which rest on the planking near the beam boxes and are left in the concrete. The concrete is delivered from the mixer to a conical, dump-bottom bucket which is hoisted to the level of the floor and run across to the proper place on a steel cableway supported by movable struts on either side of the building. The mixer, engine, hoist and one strut are mounted on the same truck and the struts can be moved along without interrupting mixing or hoisting. The concrete is placed in the floors in transverse strips 2 ft. wide, the struts being moved along the length of the building as the work progresses. The men work in two shifts, six hours on and six hours off, night and day. Thus there are no dry joints and the floor concrete is monolithic. A large canvas 90x16 ft. is stretched from strut to strut of the cableway and protects the fresh concrete from sun and rain.

The advantages claimed for this method of floor reinforcement are: The centering may be removed sooner and with greater safety than where the rods are simply lapped in the concrete. The cost of coupling is less than the extra steel required in lapping. The reinforcement gives no trouble when the concrete is being placed and the latter can be put in very rapidly. It is also believed that this system secures a more nearly perfect, continuous beam. In the case of the Baker Manufacturing Co.'s warehouse this system of floor reinforcement seemed to give the most economical construction obtainable. The floors were filled at the rate of a strip about 1½x80 ft. per hour. The concrete for the second floor, amounting to about 296 cu. yd., was mixed, placed and finished in 84 hours by 15 men, a total of 1,260 labor hours.

Two test slabs of this type of construction which were built one-half size, were loaded with pig-iron to their calculated breaking load without any sign of failure.



View Showing Reinforcement, Cableway and Protecting Canvas.

Fluorescein in the Study of Underground Waters.

In studying the potability of a well or spring water it is important to know not only its chemical composition, but also its source, its rate of flow, the area tributary to it, the nature of the material through which it passes, and the contaminations to which it may be subjected before or during its underground journey. Knowledge of this nature is especially important in the study of waters passing through formations full of seams or crevices, where there is opportunity for rapid circulation without much purification. The determination of the area draining to the underground supply affords data in regard to the quantity of available water as well as its quality. These and many other considerations make the study of conditions in the subterranean basin more important than laboratory examinations into the nature of the water itself.

For such hydrologic studies as have been indicated much knowledge may be gained by introducing some foreign material into the aquifer under study and tracing its journey by samples from wells, springs or borings along its possible course. The principal requisites in a flow indicator are: 1. It should descend to and traverse the aquifer in a manner and at a rate similar to the water itself. 2. It should be easily and quickly detectable in the samples of water taken. 3. It should not be decomposed nor its intensity greatly affected by the materials with which it comes in contact. For different purposes and in different materials the selection of an indicator is varied. For tracing the flow, however, of large or small underground streams through well-defined channels in rocks, especially calcareous formations, a material called fluorescein has proved superior to anything else which has been tried. Its diffusion is rapid, it is applicable under many conditions and it can be easily detected in enormous dilutions by means of the fluoroscope.

Fluorescein is a coal-tar product and occurs as a crystalline powder or amorphous masses, varying in color from reddish yellow to dark brown. In the presence of alkalies its solution is red by transmitted light and bright green by reflected light—a phenomenon known as green fluorescence. The red color is not apparent in a very dilute solution, but by the use of a long tube filled with the alkaline liquid the green appearance is apparent. For a flow indicator it is important to use fluoresceïn of good quality, as otherwise the coloration will not be visible in a solution sufficiently dilute. The most practical test of the applicability of a sample of fluoresceïn seems to be that it should be apparent with the fluoroscope in a dilution of 1 part in 10,000,000,000 parts of water. If weaker material is used a larger quantity is, of course, necessary. Fluoresceïn costs from $2.25 to $12 per pound.

In its perfected form the fluoroscope consists of twelve tubes of pure white glass of even bore, each 95 cm. long and about 15 mm. in diameter. Each tube is closed at its lower end by a rubber stopper blackened with powdered plumbago. A rock is provided in which the tubes are held side by side in a vertical position. When they are filled with samples the presence of fluoresceïn is recognized by the appearance, projected on the black cork, of a greenish reflection which is entirely different from the natural tint of the water though sometimes confused with it by inexperienced observers. It is often convenient to use for comparison standard tubes containing dilutions varying from 0 to 0.002 part per million. The limit of visibility depends greatly on the nature of the fluoresceïn used. It has been placed at 1 part in 10,000,000,000 of clear water, but for practical demonstration 5 parts in 10,000,000,000 is better. The limit of visibility with the naked eye seems to be 250 parts per 10,000,000,000. By comparison with tubes of known content the amount of fluoresceïn in the samples may be estimated and with this and other data the amount of seepage from one water-bearing stratum to another may be determined.

Fluoresceïn can be poured down where there is expected to be a connection with the underground flow—in general at any point of higher elevation than the water level in the bed under study. Sink holes, cesspools, privy walls, temporary borings, or the beds of degravelling streams are all desirable places to introduce the dye. A solution containing about 300 g. per liter is a convenient one for use. If it is poured down where there is no considerable flow of water toward the lower strata, such as in a dry boring or a vault, enough water should be poured on to wash it down. The quantity of fluoresceïn to be used varies with the distance traveled, the time of the journey, the size of the water sheet, and the nature of the material traversed. The amount generally employed is between ½ and 2 lb., though experiments have been made with much larger weights. In general the quantity is 2 lb. of fluoresceïn per hour for a flow of about 31,700 gal. per minute from the bed. It is, of course necessary to add enough to produce a detectable coloration in the water of the well or spring under examination. Having determined the flow of the latter, an approximation may be made of the amount of fluoresceïn necessary to insure the presence of a visible quantity in the effluent. Since, however, all of the water of the underground bed will probably not be delivered at the points of examination, the amount of fluoresceïn should be increased with the distance traveled.

A preliminary determination of the water level in the wells and springs in the region will eliminate those points round the spot that are manifestly outside of the circulation zone. All other wells or springs should be marked for examination, whatever their apparent disconnection with the water sheet under study. The most economical manner of taking the samples is hourly by concentric circles successively removed from the point of putting in the color. An agent supplied with twelve bottles is stationed at each well or spring to be examined in the nearest circle. In general, samples taken hourly for twelve hours will mark the arrival and departure of the fluoresceïn. Sampling, however, should not cease at any point until the passage of the dye or its nonarrival is established. The first sample should be a blank taken at the instant when the fluoresceïn is put down, and each should be plainly marked with the name of the well or spring and the date and hour of sampling. After the color has passed one zone of wells, the agents can be moved to another circle. The twelve samples representing the water for twelve hours are then examined in series as rapidly as possible.

The twelve tubes of the fluoroscope are filled from the twelve bottles representing one well water. Care is taken to arrange them in chronological order. Then, by looking at the tubes along their axes, those showing fluorescence can be readily selected. The examination should be made in broad daylight before a white wall. Special care must be taken to avoid a green background. By these tests the hours of arrival and of departure of the color at each point of examination are determined, and if desired the intensity of the fluoresceïn can be estimated.

Generally fluoresceïn progresses more slowly than the water in which it is suspended and on account of the greater density of its solution it tends to accumulate in low places along the route traversed. M. le Couppey de la Forest has noted that, when fluoresceïn is poured into a small stream which later widens out into a basin of still water, coloration is visible for a certain length of time in the stream below the basin; the coloration grows weaker, till finally not a trace can be found, though relatively large amounts of fluoresceïn-tinted water remain at the bottom of the basin; if finally the basin be agitated by the sudden influx of larger amounts of water, the more densely colored water will be washed out and the fluoresceïn will once more appear in the effluent. It may be conjectured that large subterranean caverns could effect a retention of fluoresceïn in a similar manner, and thus lead to a wrong conclusion regarding the rate of flow in the bed. Several instances of this character have been noted where one introduction of fluoresceïn has caused two or more distinct colored flows at springs in relation.

The usual method of expressing the rate of flow of the fluoresceïn underground is in meters per hour or feet per minute, found by dividing the horizontal distance in a straight line from the point of entry to the point of appearance by the time which elapses between the application of the solution and its first appearance at the point in question. It has been mathematically demonstrated by M. de la Forest that the rate thus expressed is always less than the real rate of progress in the subterranean stream because a certain length of time is consumed while the solution is soaking into the lower stratum.

Certain substances exert a decomposing influence on fluoresceïn. Its color is destroyed by acids and it cannot be used in waters containing any free acid but carbonic acid. A large amount of calcareous matter in solution, except the carbonates, will dissolve the dye to some extent. Peaty soils destroy the color, but ammoniacal organic matter and sandy or clayey soils have practically no effect on it.

Fluoresceïn has been extensively used by the city of Paris, France, in the study of springs from which the greater part of the drinking water is taken. An especially noteworthy experiment was conducted at Auxerre to demonstrate the passage of polluted water from a ditch through alluvial deposits of sand and gravel into a collecting gallery from which the city supply was taken. An account of this experiment, taken from a paper by M. de la Forest, illustrates the method of drawing certain conclusions from the test results.

A collecting gallery about 300 ft. long in the alluvium of the Yonne is situated 130 to 230 ft. from the river. Its top is 2.8 ft. and its water plane 4.3 ft. below the surface. A polluted brook ran directly toward the collecting gallery until within 28 ft., then turned nearly at a right angle and paralleled it at about the same distance. Its water surface was from 1.2 to 3.5 ft. above that of the gallery, from which 1,130,000 gal. of water were pumped daily. Two and two-tenths pounds of fluoresceïn were put into the brook 254 ft. in a straight line from the collecting galleries, and samples were then taken of the water pumped from the galleries. Fluoresceïn was shown two and one-fourth hours after the dye was put into the brook, and an intense coloration was clearly visible to the naked eye in about ten hours, lasting thirteen hours. By examining samples from many sources throughout the city and estimating the amount of fluoresceïn present, it was found that the city water was colored for thirteen hours at an average of 1 part of fluoresceïn in 30,000,000. During that period about 600,000 gal. were pumped from the galleries, containing, therefore, 0.17 lb. of fluoresceïn. Since 2.2 lb. were put into the brook and 0.17 lb. reached the city water, it may be estimated that the ditch water reaches the galleries in the proportion of 2.2 to 0.17, or, to allow for some small error, about one-fifteenth of the brook water infiltrates to the town supply. Since the stream flowed at that time 950 gal. a minute, or about 1,370,000 gal. a day, while the gallery consumption was 1,130,000 gal. a day, it will be seen that about 8 per cent. of the city supply was water from the polluted brook. As previously stated, it took two and one-fourth hours for the fluoresceïn to reach the filter galleries. Assuming that the infiltration extended from the point at which the fluoresceïn was put down, the coloring matter would have progressed with a rate of 113 ft. an hour through the alluvial deposits. If, on the contrary, the infiltration took place between the ditch and the gallery at the nearest point, it occurred at the rate of 12.4 ft. per hour. Assuming a maximum filtration rate of 3,000,000 gal. per acre per day for an efficient sand filter, it may be inferred that this brook water reached the collecting galleries with practically no purification.

In summarizing, nine points are called to attention by Mr. R. B. Dole, from whose paper, published by the U. S. Geological Survey in the Underground-Water Papers for 1906, these notes have been prepared: 1. In determining the sanitary value of a well or spring it is more important to study the underground flow than to analyze the water itself. 2. Foreign substances put into the aquifer and traced from point to point are of great use in this study. 3. With the fluoroscope one part of fluoresceïn can be detected in 10 billion parts of water. Fluoresceïn is a particularly valuable flow indicator for fissured or cavernized rocks. 5. It is also available in gravels, where it has been used with success. 6. It progresses at a slightly lower rate than the water in which it is suspended. 7. It is not decolorized by passage through sand, gravel, or manure; it is slightly decomposed by calcareous soils. 8. It is entirely decolorized by peaty formations and by free acids, except carbonic acid. 9. It has been used with much success for several years by the city of Paris.

Recent Experiments on Shallow-Draft Stern-Wheel Motor Boats have indicated that the stern wheel is a much more efficient propeller in shallow water than the screw propeller. A 31-ft. cabin launch of 5¾-ft. beam, having a displacement of 1,800 tons and draft of 7⅞ in., fitted with a 6-ft. stern wheel, easily makes eight knots in deep water and from 3 to 5 knots in shallow water. This motor was driven by a 16-h.-p., four-cylinder gasoline engine, which was placed well forward in the boat.

Cost of Steam Shovel Work.

Among the various jobs of grade reduction work, which were done on the Chicago, Burlington & Quincy Railway during the season of 1906, were two on the Beardstown-to-Centralia Division, known as the Big Shoal and Little Shoal cut-off, respectively. These were constructed by the railroad company and have afforded some cost data on steam shovel operation which is of special interest because the cost per cubic yard on the two jobs was exactly the same, notwithstanding the fact that the material handled and the general layout at the two places were very different.

Big Shoal Cut-off.—The Big Shoal cut-off was a change in grade and alignment between Sorento and Reno, Ill., and involved the moving of 318,711 cu. yd. of earth, 251,711 cu. yd. of which was steam-shovel work. Two temporary trestles were built having a total length of 2,961 ft., and an average height of 40 ft. Each bent consisted of two softwood piles, bracing and cap. They were spaced on 13-ft. centers and carried two 8 x 16-in. stringers, which were recovered as the embankment was completed, the rest of the lumber being buried. Second-hand material was used throughout except for the bracing.

The clay from which the embankment was built was hauled an average distance of one and a half miles from a cut, averaging in depth 15 ft. Owing to the numerous springs encountered in the cut the clay was very wet and consequently difficult to handle, the chunks leaving the dipper being sometimes as large as the dipper itself. This made the dumping of cars rather dangerous and necessitated locking them to the trestle before they were dumped. The work was delayed somewhat by the wetness of the material.

Water was supplied to the shovel through a 2-in. pipe line, laid outside the digging line and tapped every 100 ft. with a "T" connection. By means of a long rubber hose water could be delivered to the boiler at any time, thus avoiding the usual delay of siphoning water. The men ate and slept at the work and the bunk and cook houses were also supplied with water from this pipe line.

The equipment consisted of one 65-ton Bucyrus steam shovel, two switch engines, with 30 tons on the drivers, forty-three 5-yd. dump cars, and one Jordan spreader. The shovel began work on April 27, and the work was completed on Nov. 2. From June 20 to Oct. 26, a night shift was run and the total number of 10-hour shifts, actually worked by the shovel, was 228. One-quarter of the working time, which would otherwise have been available, was lost by reason of bad weather, holidays and breakdowns. The total quantity of earth handled by the shovel was, according to the cross-section measurements, 251,711 cu. yd., or 1,104 cu. yd. per 10-hour shift worked. The yardage handled per night shift was 84 per cent. of the day shift output.

The cost of the entire equipment, including the camp buildings and water supply system, was $2,732.71, or about 1 cent per cubic yard, depreciation only being charged against the shovel, engines, cars and spreader, and net cost of labor and material being charged against the buildings and pipe line. The cost of all labor on steam shovel service was 7.1 cents per cubic yard. This included the charges for manipulating the shovel, switch engines and cars, making repairs, dumping cars, and attending to the lights for night work. Supplies for the shovel, engines and cars, such as oil, coal and waste, cost 1.8 cents per cubic yard. The total cost of merely moving the earth was therefore 8.9 cents per cubic yard. The trestle cost, per lineal foot, $1.30 for labor and $1.74 for material, or at the rate of 3.6 cents per cubic yard of earth. The total cost per cubic yard for all track work, including labor and depreciation of equipment, was 4.9 cents.

Summarizing, the total cost per cubic yard was 18.7 cents, made up of the following items: equipment, 1 cent; steam shovel service, 8.9 cents; temporary trestle, 3.6 cents; track and track work, 5 cents; supervision and engineering, 0.2 cents.

The labor force charged against the day shift was as follows: a general foreman, at $118.50 per month; one steam shovel engineer, at $125; one cranesman, at $90; one fireman, at $55; one track foreman, at $75; one assistant foreman, at $55; one watchman, one timekeeper, and one pumpman, at $45 each; one conductor, at $103.50; two brakemen, at $69; two enginemen, at $4 per day; two firemen, at $2.40 per day; six pitmen, at 19 cents per hour; 10 laborers dumping cars, and thirty-eight on track work, at 16 cents per hour. The night shift was charged with a light man, at $1.75 per day, but the general foreman, track foreman, timekeeper, laborers on track and two of the men dumping cars were omitted. Moreover on the night shift the pitmen were paid 20 cents and the watchman, pumpman and laborers, 17½ cents per hour. The monthly yardage varied from 29,411 to 63,200 and averaged 41,951.

Little Shoal Cut-off.—This was a change of alignment and grades between Ayers and Durley, Ill., and involved the handling of 188,240 cu. yd. of wet material, about 40 per cent. of which was hard pan, about as solid as the shovel could dig without resorting to blasting. The temporary trestle was 2,142 ft. long with an average height of 35 ft., and was similar to the one used at the Big Shoal cut-off. The average haul was one-half mile and both engines and shovel were handled over 6 per cent. grades very easily. The equipment was the same as that used at the Big Shoal work except that only thirty-six 5-yd. dump cars were used.

The shovel began work on May 21, and finished on Sept. 30, night shifts being put on as often as possible throughout the entire period. The total number of 10-hour shifts actually worked was 199, and only 14 per cent. of the total days on the work were lost. Nine hundred and forty-six cubic yards were handled per shift, and the output per night was 78 per cent. of that per day.

The cost of equipment, calculated as at Big Shoal, was $2,910.93 or 1½ cents per cubic yard. The cost of all labor on steam shovel service was 7.7 cents per yard, the same items being included as at Big Shoal. Steam shovel, engine, and car supplies cost 1.9 cents, making the cost of actually moving the earth 9.6 cents per yard. In addition, the temporary trestle cost $1.22 per foot for labor, and $1.51 for material, or 3.1 cents per cubic yard, and the track work, figured as before, cost 4.2 cents per cubic yard. Summarizing, the total cost per cubic yard was 18.7 cents, made up of the following items: equipment, 1½ cents; steam shovel service, 9.6 cents; temporary trestle, 3.1 cents; track and track work, 4.2 cents; supervision and engineering, 0.3 cents. The personnel and wages of the two shifts were the same as at Big Shoal. The yardage per full month varied from 25,352 to 57,632, and averaged about 43,500.

In commenting on these two pieces of work, Mr. John C. Sesser, engineer of construction, C., B. & Q. Ry., from whose paper, published in a bulletin of the American Railway Engineering and Maintenance of Way Association, these notes have been taken, suggests that the work might have been done more cheaply if 12-yd., instead of 5-yd. cars had been used. Mr. Sesser also calls attention to the fact that on the Little Shoal work, the car track was at times 9 ft. 2 in. above the shovel track, in his opinion about 2 ft. higher than it should be to give the best results. It is not economy to work the shovel to its extreme limit in lift and reach.

Tests of Bond Between Concrete and Steel at the University of Illinois.

There have been a considerable number of valuable tests of the bond between concrete and steel made at the University of Illinois, which are particularly deserving of attention because they were made with plain round bars, cold rolled shafting, mild steel and tool steel, imbedded in concrete of different proportions. The experimental work was done by Mr. Todd Kirk, and a description of it with a summary of the data was recently prepared by Prof. A. N. Talbot for a university bulletin. The conclusions he draws from the experiments are the following:

Little difference is found in the bond resistance per square inch of surface of bar in contact with the concrete whether the bar is embedded 6 or 12 in. Evidently a length may be found beyond which the stretch of the steel would cause uneven distribution of the bond stress along the length of the bar and cause failure to begin at the point of the greatest stress in the steel and thus give results not representative of the real bond resistance. This limitation applies to length for use in experimental tests of bond. In simple beams the bond stresses are applied along the length of the bar, and stretch and bond exist together.

The richer mixture of concrete gives somewhat higher bond resistance than the leaner, the values for the 1:2:4 concrete averaging, say, 10 to 15 per cent. higher than the 1:3:5½ concrete. For plain round mild steel rods, the average for the bond resistance ranges from 350 to 450 lb. per square inch of contact surface.

Flat bars gave much lower resistance than round bars. Only three tests were made with flat bars, and these may not be representative. It may be noted that the results with flat bars are much lower than tests made elsewhere. It should also be noted that for a bond stress of 125 lb. per square inch, the tensile stress developed in the bar was only 9,000 lb. per square inch.

The value of bond resistance will depend upon the smoothness of the surface of the bar, the uniformity of its diameter and section, the adhesive strength of the concrete, and the shrinkage grip developed in setting. The effect of smoothness of surface and uniformity of diameter and section is seen in tests made with cold rolled shafting and tool steel. The average bond developed with cold rolled shafting and tool steel was 147 lb. per square inch of contact surface, as compared with about 400 lb. for ordinary plain, round, mild steel rods. It should be stated that not only was there a very noticeable difference in the smoothness and finish of the surface of the rods, but the section of the cold-rolled shafting and tool steel was very uniform, the diameter not varying more than 0.0001 or 0.0002 in. at ¼-in. intervals throughout the length, while mild steel rods will vary as much as 0.0015 in. It is to be expected that the smoothness and uniformity of section of drawn steel wire will operate to give low values of bond resistance, though, of course, as the section of wire is small compared with the circumference, the bond stresses developed when wire is used are relatively small. Attention is called to the fact that in the reinforced concrete beams tested at the University the bond stresses developed in beams failing by tension of the steel, diagonal tension of the concrete or other similar methods amounted to from 73 to 193 lb. per square inch. Even at the breaking load, then, the bond stress developed in the mild steel rods was far below the bond resistance found in these tests.

In these tests the bars began to slip when the maximum load was reached. After slipping began, the resistance to motion was still considerable. This running friction, taken when the bar had moved about ¼-in., amounted to 54 to 72 per cent. of the bond developed in the case of mild steel bars and to 32 to 49 per cent. in the case of the cold-rolled shafting.

Book Notes.

In his "Outlines of Practical Sanitation," Dr. Harvey B. Bashore, an inspector for the Pennsylvania Department of Health, furnishes an elementary statement of the measures necessary to preserve the public health. The author explains the sanitary precautions to be taken in connection with habitations, water and sewerage systems, refuse disposal, milk and food supplies, schools and cars. He explains in a very general way the cause and prevention of contagious and infectious diseases, shows the importance of vital statistics in revealing an increase in any disease, and gives a general statement of what can be accomplished by public sanitary measures in cities and in the country. Finally he furnishes some hints concerning personal hygiene. There are a few things in the book that are hardly correct from an engineering standpoint and others that are impracticable for most of us, such as walking 8 or 9 miles daily for exercise, but there is nothing that will work harm and it is really a valuable little volume for those who are interested, as everybody should be, in public health. (New York, John Wiley & Sons; $1.25.)

Every year the University of Manchester awards two or three Gartside scholarships to young men from 18 to 23 years old, who follow a course of study at the University and then spend a year examining subjects connected with commerce or industry in Germany, Switzerland or the United States. Mr. Frank Foster held such a scholarship in 1904-05, and in his "Engineering in the United States" he gives a report of his observations in this country, part of the time as a workman in a power plant and in a manufacturing establishment, and part of the time visiting works and educational institutions. The book is an interesting statement of how our methods appear to a well-educated young Englishman, who is not disposed to consider everything poor which is unfamiliar. Some of the things he discusses are well worth looking at from a binational view-point, such as trade unionism in the two countries, the shifting character of shop employees in this country as compared with England, manual and technical education, wages and cost of living, workshops, and central power stations. (Manchester, Eng., University Press; 1 shilling.)

More than a generation ago John Ericsson, the famous inventor, who was a remarkably skilful draftsman, was accustomed to tell his assistants to make their drawings "talk." The same idea was expressed three years ago in a paper on mechanical drawing in the modern drafting room, read by Mr. George H. Follows before the Engineers' Society of Western Pennsylvania. This paper attracted much attention, and in response to requests from colleges it has been elaborated into a text-book with the title of "Universal Dictionary of Mechanical Drawing." It is based on the same idea that Ericsson held, that a good mechanical drawing was a form of language, which should be studied and practiced until those using it become as clear and concise as the users of good, forceful English. It is a good book, and will be helpful to all engineers who desire to have their drafting done in the best manner. The author's former connection with the engineering department of the Westinghouse Electric & Mfg. Co. has enabled him to illustrate his text by drawings made for that company, while the drawings made specially for the book are excellent. (New York, Engineering News Publishing Co., $1.00.)

A book that will be welcome to an unusually wide circle of readers is Mr. Burton R. Leffler's "The Elastic Arch," written with special reference to the reinforced-concrete arch. The author has prepared this little manual from the point of view of an engineer who has had to direct draftsmen in designing reinforced-concrete girders and arches, and as a result the information he furnishes is admirably concise and to the point. A large amount of such work has been done on the Lake Shore & Michigan Southern Ry., of which the author is bridge engineer, and the methods explained are those used there. In the first part of the book he follows, step by step, the graphical analysis of an arch of 33-ft. span and 15-ft. rise for a Cooper E60 loading, with impact added. There is no theory in this part, as the purpose is to present the actual drafting-room methods, which is done in a model manner. The reader is assumed to know elementary mathematics, the mechanics of materials and the theory of the equilibrium polygon, but the process of making the drawings is so well explained that there is no serious strain on the draftsman's knowledge in following the directions. The author states that a large solid arch should be analyzed for at least four positions of the live load, full, three-fourths, half, and one-fourth. Two draftsmen can do this, design the sections and determine the width of the abutments in about 30 hours' work, if it is systematically arranged. In the second part of the book, the theory of the elastic arch is explained in such a manner as to show the reasons for the practical graphical method of design recommended previously. The logical steps are stated clearly, but it would be well in subsequent editions to state certain reductions and assumptions in the simplification of formulas which are left to the reader to work out. Such problems are entirely appropriate in a school book, but in a manual for engineers' use, everything should be explained which will assist the reader. In the third part of the book the analysis of an unsymmetric arch, having its abutments on different levels, is explained. In the method previously employed, the arch was divided into sections of equal length along the gravity or neutral axis, but for unsymmetric arches the axis is so divided that the quotient of the length divided by the moment of inertia of each section remains constant, a method of subdivision used by Prof. Wm. Cain in his monograph on "Steel Concrete Arches." Mr. Leffler's method is to resolve all oblique forces into components that are vertical and parallel to any desired oblique line. The vertical loading is cared for as previously explained, while the treatment of the oblique components forms the subject of this part of the book. Finally, of course, the two pressure curves must be combined. In the fourth part of the book, the author gives his views regarding various subjects connected with reinforced concrete designing. (New York, Henry Holt & Co.)

In view of all the books now in print regarding the elementary principles of applied mechanics relating to engineering structures and the strength of materials, it takes some courage to write another. This has been done, however, by Prof. S. E. Slocum, of the University of Cincinnati, and Prof. E. L. Hancock, of Purdue University, whose "Text-book on the Strength of Materials," has just been published. In a good many respects it is an excellent book, for it does not descend to any lowly plane of mathematical impotence, but assumes that the reader has been properly trained to take up the subject, and that the instructor using the book for class-room purposes will not consider it undignified to help students who may find some sections a little troublesome to grasp at first. It is refreshing to have a book that does not secure clearness by descending to words of one syllable nor envelop simple things in the rags of owlish pedantry. The book is not overloaded with demonstrations of formulas which have been taught in lower classes, and by eliminating the information on the subject given in the text-books appropriate to those classes space is saved for carrying many of the topics farther than is done in most books of this nature. These advanced subjects are at the ends of the chapters to which they relate, and are so marked that they may be omitted by those seeking a strictly elementary course. The contents of the volume are divided into two portions, one on the mechanics of materials and the other on the physical properties of materials. In the first two chapters there is a general discussion of the relations between stress and deformation, and demonstrations of certain elementary theorems which serve as a basis for special rules of calculation subsequently developed. The analysis of stress in beams is next taken up, and after that flexure in beams. The discussion on columns and struts is particularly good for the use of engineering students. Torsion is taken up next, and it is gratifying to notice that St. Venant's investigations of non-circular shafts are properly summarized, something that has rarely happened since Rankine started the practice of misquotation. Spheres and cylinders under uniform pressure next receive consideration, and the unsatisfactory subject of flat plates is then discussed by Bach's method, which is probably as good as any. A chapter on hooks, links, springs and curved pieces gives information not found in other elementary books. The subject of arches and arched ribs is introduced by an explanation of the graphical analysis of forces; this is followed by a discussion of concrete and masonry arches, and a general explanation of the method of determining the stresses in arched ribs. The first part closes with a chapter on foundations and retaining walls. The second part gives a good collection of data relating to the properties of iron, steel, lime, cement, concrete, reinforced concrete, brick, building stones, timber, rope, wire and belting. A uniform system of notation is employed throughout the book, and an unusually good collection of examples is interspersed through the chapters of the first part. It is a book which deserves the attention of instructors, while engineers who wish to review the subject will find it particularly useful because of its concise text and its presentation of many things omitted from most books of this sort. The typography is of the high standard maintained in all books issued by the publishers. (Boston, Ginn & Co.; $2.)

A remarkable book, which deserves a much more extended notice than its interest to the readers of this journal permits, has been prepared by Mr. G. W. Littlehales, of the hydrographic bureau of the Navy Department. It is entitled "Altitude, Azimuth and Geographical Position," and is a 23x14-in. atlas of 368 plates for finding graphically the altitude and azimuth, the position line, and the variation of the compass; and for identifying observed celestial bodies, and finding the course and distance in great circle sailing. The author's object in preparing the plates, which must have required a great amount of patient work, was not only to simplify and shorten the labors of scientific navigators and geographical explorers, but to open to all navigators the field of astronomical navigation which has heretofore been restricted to those of higher education. The researches of mathematical navigators during the last century were directed chiefly to the abridgement of the processes of logarithmic computation. But the practical seaman has little leisure, even if he have the taste, for long numerical computations, and in seeking to satisfy the demands for processes that are brief and yet accurate within the requirements of navigation, logarithmic and numerical computation have been almost swept away in the present method. The problem of identifying the celestial body that has been observed and of simultaneously finding the true bearing and the summer line of geographical position with as much precision as astronomical observations taken at sea will warrant is treated in this book as if the co-ordinates of the celestial sphere had been plotted from minute to minute of arc throughout the whole circuit of the heavens in such a manner that the diagram, being entered with the latitude of the observer and the declination and hour angle of the observed celestial body, will give the corresponding altitude and azimuth of the observed body. The difference between the instrumentally measured true altitude and the altitude thus read from the diagram gives at once the means of laying down the summer line; and the difference between the bearing of the celestial body as observed by the compass and the true bearing or azimuth as thus read from the diagram gives the total error of the compass. The diagram, which is separated into numerous parts without interfering with its usefulness, may also be entered with equal facility with the latitude, altitude and azimuth as arguments for the purpose of taking out the hour-angle and declination in order to identify any celestial body whose altitude and azimuth have been observed. In short, the book furnishes a sure and simple solution of all problems of navigation and astronomy that depend upon the solution of a spherical triangle in which two sides and the included angle are given. (Philadelphia, J. B. Lippincott Co.; $25.)

Letters to Editor.

The Victoria Falls Development.

Sir: Your recent statements regarding the development of power at the Victoria Falls on the Zambesi River, and its transmission over seven hundred miles to the Rand, find striking confirmation in to-day's "Engineering," where there is a letter on the subject from Sir Alex. B. W. Kennedy, giving the substance of an investigation of the project made for the Rand Central Electric Works, Ltd. The importance of this project from a technical standpoint is so great that his statements should be given publicity on your side. He first takes up the amount of power required in the Rand. The total horsepower in the mines on the Rand is officially given as about 230,000. Of this, however, about half is used in mines whose probable life does not exceed fifteen years, and may, therefore, be left out of account. Of the remainder, about 25 per cent. is used at present in the form of compressed air at the faces, where it is unlikely that the electric will supersede the pneumatic system; of what is left, something like 12,000 h.-p. is already electrical, so that the total possible future market in the Rand, so far as can be seen, is about 75,000 h.-p. Considering the large capital expenditure required for electrification, and the varying views of mining engineers as to the extent to which it is feasible to use electricity in the mines, it will be seen that a total of 50,000 h.-p. represents a somewhat sanguine estimate, and that the preliminary amount of 20,000 h.-p., now being spoken of as a small first instalment, really represents a fairly large proportion of the possible demand.

The Victoria Falls scheme is to start with the erection on the Rand of an ordinary steam station on modern lines, containing about 20,000 h.-p. in boilers, steam turbines, and dynamos. This, of course, would be in itself a reasonable and proper scheme if it is not to be grossly over-capitalized. But although it may be shrewdly suspected that this station, if it were ever constructed, would be the end as well as the beginning of the enterprise, Sir Alexander feels bound to assume, at least on paper, that the scheme for which the public is to find money is something enormously greater.

First of all, then, comes an ordinary 20,000 h.-p. steam station. Next a huge low-level reservoir with electrically-driven pumps, to utilize a part of the power coming from the Falls for pumping water into a second reservoir 600 ft. above the first. Then pipe-lines coming down again connected to separate turbine-driven electrical plant, again of 20,000 h.-p., so that at this stage we have 40,000 h.-p. of dynamos, 20,000 h.-p. of steam plant and the same of turbines, and 6,000 h.-p. (more or less) of electric motors and pumps; two reservoirs, each of about 20 million gallons capacity, with their dams, etc., and two high-pressure pipe-lines, all for a gross delivery of 20,000 h.-p. to the mines.

The reservoirs are to be large enough to contain water for driving the 20,000 h.-p. turbine plant for twelve hours continuously in case of breakdown. This hydraulic arrangement, according to Mr. Wright, "enables an interruption of more than twelve hours of the transmission line to occur before the steam reserve station need actually be put to work," so that it "renders unnecessary the very heavy cost of keeping the reserve station always under steam throughout the year." Further, Mr. Wilson Fox says that the erection of a steam reserve station on the Rand "is a sine qua non demand on the part of the mine owners," at which Sir Alexander is not at all surprised.

Then, in addition to the plant mentioned, the complete scheme provides that each 20,000 h.-p. at the Rand must have (*a*) about 30,000 h.-p. of turbines, dynamos, and transformers at the Falls; (*b*) 700 miles of high-tension transmission line; (*c*) 20,000 h.-p. of transformers, etc., at the Rand. It strikes one as rather a large order to have to provide about 70,000 h.-p. of dynamos alone and 50,000 h.-p. of turbines, not to mention the 700 miles of transmission line, the steam engines, reservoirs, pumps, pipe-lines, and so on, for the sake of 20,000 h.-p. on the Rand itself.

As a matter of comparison, and as showing what the real financial magnitude of the business is on a proper commercial scale, it is interesting to notice how the Rand Central Electric Works, who are not asking the public for any capital, are situated now that they are extending their plant on modern lines, with the intention of supplying cheap power on a large scale. They possess an excellent site near the coal-fields, where they are now obtaining coal under 10s. a ton; they have a 12,000-volt transmission line already erected along the Rand, they have long ago obtained full power to supply the mines wherever current is required, and they also have acquired the right to put up a new transmission line along the Rand, at 50,000 volts, for power purposes. The total cost of extending the Rand company's present plant by an amount of 20,000 h.-p., and putting down the corresponding transmission lines along the Rand, is estimated at under £400,000, and tenders for the first section of the plant are at present under consideration. The total cost of this plant will, therefore, be about £20 per horse-power, and the whole capital charges upon it, allowing for interest at 6 per cent., and for ample depreciation, will not exceed 0.16d. per unit sold to the mines.

The total cost of the Victoria Falls Power Co.'s complete triple system cannot be less than £100 per horse-power. The capital charges alone on this will amount to about 0.80d. per unit. As power must be sold for something under 1d. per unit, it is obvious that practically the whole price is swallowed up in capital charges, before anything whatever is put down for working, maintenance and management, including the "proper patrolling" of 700 miles of veldt, and the "sufficient number of breakdown gangs." Besides all this, it is understood that £1,000,000 in ordinary shares is to be paid for the Victoria Falls concession. As the interest on this sum at 5 per cent. would much more than pay for the whole of the feed-water for 50,000 h.-p. at a steam station at the Rand price of 3s. per 1,000 gal., it is also not easy to see where the boasted saving in this item, at any rate, comes in.

Faithfully yours, Subscriber.
Westminster, Dec. 14.

The Design of Slabs.

Sir: In a recent editorial you mentioned the uncertainties that surround the subject of designing slabs of reinforced concrete. When I began the article I was in hopes that you would furnish some hint of your opinion regarding the solution of this problem, but found to my regret that you gracefully sidestepped the issue in a little dissertation on the complexity of the subject and the factors which make it so. The only reason I mention the matter was because I have found the data you published from time to time concerning the loads carried by floors were very useful, in spite of the fact, pointed out by your correspondents, that the tests are generally vitiated as beam tests by various imperfections in the methods of loading. It is a simple matter for anybody who has studied the subject carefully to design reinforced concrete beams and girders, but we all have to guess at what is the strength of floors, and tests which show what floors carry safely are of importance on this account, although it seems to me that their importance can be exaggerated. The reason for this last belief is that fine cracks may appear under load, and dust may settle into these cracks; when the load is removed the dust will prevent the return of the beam to its exact original shape and a reflex stress therefore results. This action may be continued until a serious condition results. For this reason the loads that may be safely imposed on a floor may be considerably less than those indicated by slab tests. Inasmuch as this subject of slab design is the most complex feature of reinforced concrete work at the present time, will you be good enough to state what system of computation you prefer?

Yours truly, Alfred Jackson.
Buffalo, Dec. 22.

[Probably the Bach method of designing flat plates is as good as any; it is the one preferred by this journal, and is explained in all up-to-date books on the strength of materials. As a matter of fact the uncertainties regarding the subject are very great, and the editorial referred to in the above letter was intended to point out that some formulas of apparent exactness are really nothing but rough approximations. The design of slabs is often turned over to young draftsmen who do not appreciate the serious dangers of poor materials and workmanship in reinforced concrete construction, but rely wholly on formulas which should be considered rather as helps than infallible guides.—Editor.]

One Year's Service with the Steam Turbine Propelled Cunard Liner, the Carmania, has shown results in excess of expectations. During the entire year the turbines have not been opened or needed any unusual attention. When the ship was first placed in service, the turbines were run only at a moderate speed as a precautionary measure, with a result that a rather low efficiency in operation was secured. In later voyages, the turbines have been speeded up, and it is interesting to note that the coal consumption is now almost identical with that which might be expected from the best quadruple expansion engine construction.